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Work performed for
U.S. DEPARTMENT OF ENERGY
Fossil Energy
Office of Coal Utilization

Prepared for
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A PROGRAM-MANAGEMENT PLAN WITH CRITICAL-PATH DEFINITION FOR COMBUSTION
AUGMENTATION WITH THERMIONIC ENERGY CONVERSION (CATEC)

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ABSTRACT

Thermionic energy conversion (TEC) deserves consideration for topping any conversion or process system that receives heat from an energy source at much higher temperatures: In recent TEC-topping analyses, overall plant efficiency (OPE) and cost of electricity (COE) improve slightly with current capabilities and substantially with fully matured technologies. And enhanced credibility derives from proven hot-corrosion protection for TEC by silicon-carbide clads in fossil-fuel combustion products.

Combustion augmentation with TEC (CATEC) affords minimal cost and plant perturbation, but with smaller OPE and COE improvements than more conventional topping applications. However risk minimization as well as comparative simplicity and convenience favor CATEC for early market penetration. Therefore a program-management plan is apropos. That plan, its inputs, characteristics, outputs and capabilities are subjects of this report.

Executive Summary

The demonstration of hot-corrosion protection by silicon-carbide clads in fossil-fuel combustion products confers credibility on proposed terrestrial applications of thermionic energy conversion (TEC): Now the gamut of TEC topping and process-heating proposals commands the respect of reality. And topping-study results predicting higher overall plant efficiency (OPE) and lower cost of electricity (COE) for current TEC technology mean savings of fuel and funds - here and now.

An interesting concept generalizes topping through combustion augmentation with TEC (CATEC): In this approach TEC protects combustor walls, pre-heats combustion air, delivers suitably cooled effluent to lower-temperature conversion or process systems, and generates additional electric power. All these desirable effects derive from modifying or replacing combustors, not from building new topping plants. Of course CATEC operates on a relatively small fraction of the total plant energy throughput. But it increases OPE and reduces COE with demonstrated TEC capability and minimal plant perturbation. Furthermore this method of skimming the high-temperature cream off combustion Carnot cycles applies to fluid-fueled atmospheric, pressurized and even coal-fired combustors.

In fact those three phases constitute a program proposed to develop CATEC in atmospheric, pressurized and coal-fired versions. Near the end of July 1980 developmental steps detailed by DOE project management underwent review and revision of precedences and durations by the program management in consultation with primary contractors (Rasor Associates Incorporated (RAI) and Thermo Electron Corporation (TECO)). At that time condensed critical-path Gantt charts for the three CATEC Program phases were available, projecting through applications development and support (ADS). Then cooperative efforts with Aerospace Corporation (AC) began to adapt CATEC plans to the computerized Program Management System (PMS) that they provide to DOE.

In the interim (early December 1980) TECO, Brown Boveri Turbomachinery (BBT) and RAI, United Technologies Corporation (UTC) teams presented results from separate studies of CATEC used with combined cycles and integrated coal gasification: Although the approaches differed considerably, the findings were consistent - higher OPE and lower COE with current TEC capabilities. The gains for existing pressurized-CATEC technologies are equivalent to about a 200°F increase in gas-turbine-inlet temperatures initially ranging up to 2200°F (over 370°F for second-generation TEC and still higher for the third generation).

Now various AC PMS outputs are available for CATEC ADS. This report presents and discusses some of these computerized implementations for programmatic guidance and control.

Topping with Thermionic Energy Conversion (TEC)

Several years ago a paucity of TEC-topping papers existed. Although the number of such publications available today is not plethoric, it is adequate to project TEC-topping potentialities (refs 1 to 21). Analyses indicate definite improvements in overall plant efficiency (OPE) and cost of electricity (COE) with TEC topping of plants (TEC TOP) for lower-temperature conversion or process systems energized by fossil-fuel combustion: These predicted gains are small for current TEC-TOP capabilities but substantial for fully matured technologies.

Such implications encourage the inference that terrestrial applications of TEC are assured. But without hot-corrosion protection from fossil-fuel combustion products, TEC TOP and its high-temperature, high-power-density benefits (refs 12, 13 and 17) are inaccessible. However the technology evolution necessary to break the hot-corrosion barrier is apparently at hand as reference 21 indicates:

Silicon-carbide (SiC) clads for TEC in topping of powerplants arose as a promising solution to this hot-corrosion problem (refs. 1, 13 to 17 and 22 to 28) during pre-1970 Office of Coal Research contract studies. Reference 1 reports on the thermal-shock stability, thermal-expansion compatibility, molten-slag resistance and hot-corrosion protection of SiC-clad TEC. Recent EPRI-supported work on coal-fired recuperators and regenerators further supports SiC as a high-temperature heat-receiving surface.

Now Thermo Electron Corporation (TECO) is testing a series of SiC-clad TEC diodes in fossil-fuel combustion products. One with a 1730 KW emitter passed 3500 hours (early December 1980) and is continuing (over 4700 hours in mid January 1981). Tests after over 5000 hours for another SiC-clad converter with a 1630 KW emitter yielded gratifying results (ref. 28):

"Electron microprobe analysis showed no evidence of any reaction between the interfaces of the tungsten, graphite, and silicon carbide. X-ray diffraction patterns of the silicon carbide were compared to those from unfired silicon carbide. The patterns were essentially identical and showed primarily silicon carbide. Knoop microhardness tests indicated there was no change in the hardness during the life test. The hardness at the dome was KHN 2600. The

following impurities were found on the dome area of the hot shell: aluminum, magnesium, potassium, and iron. The first three probably originated from the furnace firebrick and the iron from the melted flue pipe. Significantly, no chemical reactions between these elements and the silicon carbide were indicated. Apparently, no change or degradation to the composite shell resulted from the 5000 hours operation."

TECO also revealed that TEC fabrication based on chemical vapor deposition (CVD) with suitable SiC cladding is more economical than conventional fabrication for lower-temperature superalloy protection. The laminar W, graphite (C), SiC dome (emitter, thermal-expansion adapter, protective coating) can also be manufactured on reusable mandrels. So directly-fired TEC appears cost-effective as well as feasible. TECO has also demonstrated adaptability of their methods to produce SiC-clad MFHP (metallic-fluid heat pipe) envelopes.

Now TEC TOP definitely appears credible.

A special adaption with broad applicability is combustion augmentation with TEC (CATEC): Here combustor wall protection, combustion-air preheating, supply of appropriately cooled effluent to lower-temperature conversion or process systems and additional power generation all derive from TEC. And although the heat passing through TEC in CATEC is a relatively small fraction of the total plant thermal power, existing capabilities allow definite OPE and COE improvements that increase substantially for fully matured technology. Furthermore fluid-fueled and coal-fired atmospheric CATEC as well as pressurized versions enable TEC TOP with minimal cost and facility perturbation. Therefore the market-penetration probability appears promising for CATEC.

For these reasons this report presents a brief description of CATEC and a pertinent program-management plan with critical-path definition.

Current CATEC Capability for Combined Cycles with Integrated Gasifiers

Most OPE, COE evaluations for advanced conversion systems compare results derived from projections of fully matured technologies (fig. 1, ref 17). Perhaps this comparison is as equitable as any because all specimens are cut after ramming them against technological end-stops which are subject to detailed examination and discussion. The other extreme of the comparative distribution includes those conversion systems already in operation. The spectrum between these limits is variegated with differing degrees of completion, competitiveness and conscience. So the "take your best shot" approach seems a legitimate one.

But estimating near-term market-penetration probabilities requires determinations based on current capabilities. Operating under such a mandate Rasor Associates, Incorporated (RAI) and Thermo Electron Corporation (TECO) presented conceptual analyses of pressurized CATEC with gas turbines and combined cycles to Department of Energy (DOE) representatives in the spring of 1980: Existing TEC performance and fabrication technologies enable small improvements in gas-turbine and combined-cycle OPE's and COE's. The gains for current pressurized-CATEC capabilities can also be characterized as equivalent to about a 200°F increase in gas-turbine-inlet temperatures

initially ranging up to 2200°F. For second-generation TEC this effective gain is over 370°F - still higher for the third generation.

More detailed analyses of effects for existing pressurized-CATEC technologies utilized with combined cycles having integrated gasifiers became available to DOE in December 1981: Then TECO (Brown Boveri Turbomachinery, Stone and Webster Engineering) and RAI (United Technologies Corporation, Foster Wheeler Development Corporation, Bechtel National Incorporated) teams presented findings for initial design studies and cost evaluations. Those results with descriptions and discussions will be issued shortly as RAI and TECO topical reports for DOE.

Interim indications of improvements possible for current CATEC capabilities used with combined cycles having integrated gasifiers are a 3.7% increase in OPE (70% marginal efficiency) and a 2.5% decrease in COE (marginal COE 15% lower than baseline). Fully matured CATEC technologies should effect half-order-of-magnitude gains over these enhancements.

As previously observed only about 10% of the total plant thermal-power throughput enters the TEC in CATEC. So large TEC-TOP improvements like those of figure 1 and the increase from 43.4% to over 51% (ref. 17) for MHD, steam "reference plant 3" (ref. 29) are impossible. And CATEC performance is even further from efficiencies over 40% predictable for fully matured high temperature, high-power-density TEC used alone to convert fossil-fuel combustion directly to bath-side low-voltage direct current for electrolytic plants. But CATEC requires only combustor modification or replacement - not complete new plants. CATEC offers relatively low cost, low plant perturbation: low risk.

A CATEC Program-Management Plan

The CATEC concept originated in the TEC applied-research and technology (ART) program supported by DOE. When conceptual CATEC analyses revealed feasibility, even for current TEC capabilities, more intensive work began on an expansion of that section of the program-management plan:

100000	TEC ART
110000	TEC Materials
120000	TEC Interfaces
130000	TEC-Material Deposition
140000	TEC Plasmas
150000	TEC Electrodes
160000	TEC Enhancement
170000	TEC-Converter Performance (Efficiency and Life)
180000	TEC-Module Performance
190000	TEC-Applications Analyses
200000	TEC-Heating ART
210000	Combustor Innovations
220000	Furnace Adaptations
230000	Repowering Developments
240000	Heat-Transfer Intensifiers
250000	Compatible Protective-Clad Systems
260000	Heat Pipes
270000 to 290000	To Be Assigned
300000	TEC Applications Development and Support (ADS)
310000	CATEC
320000	TEC TOP: Steam Turbines
330000	TEC TOP: Advanced Conversion Systems

340000	TEC Process Heating
350000	TEC Cogeneration
360000	MHD, TEC, Steam Systems
370000	Advanced TEC Applications (Lasers, Fusion...)
380000 and 390000	To Be Assigned
400000	TEC Field Evaluation and Demonstration (FED)
410000 to 490000	Similar to 310000 to 390000 at Expanded Level
500000	TEC Commercial Activation and Operation (CAO)
510000 to 590000	Similar to 410000 to 490000 at Expanded Level
600000 to 900000	To Be Assigned

Of course the program-management-plan section of interest in this report is 310000: CATEC.

Project Management for the DOE TEC Program fleshed out a three-phase CATEC ADS plan for fluid-fueled atmospheric, pressurized and coal-fired versions (refs. 30 to 33). In July 1980 DOE Program Management in consultation with primary contractors (RAI and TECO) reviewed precedences and durations for the numerous steps of the proposed CATEC ADS schedule. And by the end of July 1980 condensed Gantt charts for the three phases of the CATEC ADS plan were available.

Subsequently cooperation with The Aerospace Corporation (AC) initiated adaptation of the three-phase CATEC-ADS plan to the computerized Program Management System (PMS) provided to DOE. A brief report by AC project professional Harsha Reddy follows directly.

ABSTRACT

A project to provide the DOE, Division of Fossil Energy, with a Critical Path Method (CPM) Program Management System (PMS) for the Thermionic Energy Conversion Program is described. This system will be used to facilitate mission-oriented program planning, replanning; program management, redirection; resource allocation, reallocation; and response to (1) higher levels within DOE, (2) congressional inquiries, (3) executive department requests (for example OMB) and (4) other sources of question or interest.

INTRODUCTION

The Aerospace Corporation has performed computer modeling activities for the Manager of the Thermionic Energy Conversion Program in Fossil Energy by structuring the program management system for thermionic energy conversion research, development and demonstration (RD&D). This management system will be used for subsequent replanning, management and control.

This system has been applied to other energy RD&D programs and generally includes (1) program modeling, (2) network analysis, (3) special network activities and (4) requirements analysis for critical-path-method (CPM) transition. In the case of thermionic energy conversion only program modeling and network analysis were performed; further effort has been postponed until program funding uncertainties are settled.

OBJECTIVE

This project was undertaken to provide a program planning and management tool to facilitate mission oriented program planning, replanning, program direction, redirection; resource allocation, reallocation; and response to (1) higher levels within DOE, (2) congressional inquiries, (3) executive department requests (for example OMB) and (4) other sources of question or interest.

IMPLEMENTATION

A proprietary CPM software package called "Project 2" was used. This package was originally used for planning and management of construction projects. Aerospace has pioneered its use for RD&D program planning, replanning and management.

The system comprises a primary data base and eight processors for basic network analysis, CPM scheduling, target (schedule) processing, network graphics, resource and cost allocation, resource constraining, multi-project processing and project cost processing. This combination enables the user to conduct a wide spectrum of planning, scheduling, and resource requirement analyses, as well as providing a program and project progress tracking capability. Over 60 different reporting formats may be generated, allowing the individual user to select those which are most useful and which are consistent with the printing and graphics equipment available.

The following five formats were generated for the Thermionic Energy Conversion Program:

1. Planning Schedule - a format lists activity numbers, descriptions (titles), activity durations, early and late start and finish times by calendar date, as well as month number (within the program calendar), and "float" or allowable slippage time. It also identifies "successor" activities by assigned number.
2. Network Analysis - this format displays activity chronology (duration, start and finish, float) as well as precedent and successor data (number, name and nature of relationship).
3. Network Listing - a basic listing by numbers of activities in the network gives durations.
4. Network Plot - a graphic displays activities and milestones, giving chronology and depicting the interties between activities. Critical paths are identified.
5. Gantt (Bar) Chart - various forms can be generated showing early and late starts and durations.

STATUS

To initiate the program modeling activity NASA LeRC, Cleveland, who are the technical coordinators of the DOE Thermionic Energy Conversion Program, provided a work-breakdown structure. Using this structure a network was generated. Later in the development, detailed descriptions of activities pertaining to research, development and technology (RD&T) and combustor augmentation with thermionic energy conversion (CATEC) were made available. Some modifications of the original network make it consistent with the descriptions. No detailed work-breakdown structure for the alternate applications of thermionic energy conversion were available; therefore they were not included in the network. A code structure for the activities of the Thermionic Energy Conversion Program was developed based on that of the Phosphoric Acid and Molten Carbonate Fuel Cell programs.

At this juncture funding issues for the TEC Program are not resolved and the future of the program is uncertain; therefore DOE directed Aerospace to suspend the program modeling activities until further notice.

The enclosed set of reports includes the latest information received from the program participants. This information is also stored on computer tape at the Aerospace Corporation for future reference.

Selected Outputs from the CATEC-ADS Management Plan

Of the various AC PMS outputs for CATEC ADS three epitomize the scheduler guidance and control with comparative compactness: The "Planning Schedule," "Bar Chart Graphics" (Gantt Chart) and "Activity-on-the-Node Network Diagrams" project accomplishments required to complete the three-phase CATEC-FED Program by November 1, 1989 after initiation on January 1, 1982. Although the practical and desired approach requires beginning all three CATEC phases (31...0, fluid-fueled atmospheric 31...1, pressurized 31...2 and coal-fired 31...3) at once and finishing each as soon as possible (Planning Schedule "early" dates and Gantt Chart closed bars), the outputs also show "lag" times corresponding to a simultaneous finish (Planning Schedule "late" dates and Gantt Chart open-top bars). These are exemplary demonstrations of PMS versatility and adaptability.

In addition to 31.... designating CATEC and 31...0 to 31...3 relating to all or each of the CATEC phases the third digit from the left indicates a generic activity category; the fourth, a specific activity area; and the fifth, the particular activity serial number. For example 3110.. means CATEC Feasibility Studies; 3111.., CATEC Performance Inputs; and 311110, TEC Performance Inputs and Modeling, which apply to all three phases. This activity 311110 stands at the beginning of all the PMS outputs for CATEC ADS included here.

Perhaps the most informative of these but also the most cumbersome is the Activity-on-the-Node Network Diagram. This form clearly shows the program flow as well as the critical-path characteristics and activities.

Individual activity sheets for AC PMS also carry detailed resource and accounting information as well as technical descriptions and accomplishments. Thus in addition to program planning, management and adjustment this form of computer implementation facilitates effective archival capability.

Initiating and maintaining such a PMS project absorb substantial resources for some time. And this may not be advisable for all programs - particularly small, strongly ART types struggling to maintain a critical activity level. But after the throes of initiation, debugging and submission to the reporting regimen, PMS offers some definite guidance and control advantages.

Essential TEC ART (100000 series) and TEC-Heating ART (200000 series) are absent in all PMS outputs related to the "critical path method" (CPM). This absence derives from a primary premise (Project 2 Basic Manual): "CPM was designed for and is useful on projects where the duration of each activity can be estimated with reasonable certainty." And research defies scheduling.

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APPENDIX - SYMBOLS

Demo	demonstration
Des	design
DP	decision point
Estin	estimation
Eval	evaluation
Fab	fabrication
Fac, facil	facility, facilities
Facil(s)	facilitation(s)
FED	field evaluation and demonstration
GT	gas turbine(s)
Heat exch	heat exchanger(s)
HP	heat pipe(s)
HX	heat exchanger(s)
Ident	identification
Indus	industry, industries, industrial
Install	installation(s)
Instr(s)	instrument(s), instrumentation
Integ, integ	integration
I/F	interface
Maint	maintenance
Modif	modification(s)
P&C, P and C	performance and cost
P&L, P and L	performance and life
Perf	performance
Prog	program
Proto	prototype(s)
Seg	segment(s)
Sel	selection(s)
Spec	specification(s)
ST	steam turbine(s)
Syst	system(s)
TEC	thermionic energy conversion
TEC ART	TEC applied research and technology
Verif	verification(s)

TABLE I

NASA LEWIS RESEARCH CENTER										AEROSPACE CORPORATION					
RUN DATE 22JAN81 0816HRS					P L A N N I N G S C H E D U L E					PROJECT START 1JAN82					
PROJECT THERM THERMIONIC ENERGY CONVERSION										ORIGINAL COMPL. 1NOV89					
										PAGE 1					
										FF		TF			

TABLE I - Continued.

SORT NODES											PAGE 2
ACTIVITY	DESCRIPTION			MODE=O/F	CODE	DURATION	START		FINISH		FF TF
							EARLY	LATE	EARLY	LATE	
311541	CATEC-COMPONENTS COST	INPUTS(COMBUSTOR)			0	2	1JAN82	1FEB84	1FEB82	1MAR84	0 25
	PRECEDES	311711	311721				1	26	2	27	
311542	CATEC-COMPONENTS COST	INPUTS(COMBUSTOR)			0	2	1JAN82	1MAR83	1FEB82	1APR83	0 14
	PRECEDES	311712	311722				1	15	2	16	
C 311543	CATEC-COMPONENTS COST	INPUTS(COMBUSTOR)			0	2	1JAN82	1JAN82	1FEB82	1FEB82	0 0
	PRECEDES	311713	311723				1	1	2	2	
311611	GT,ST,CC AND INDUS P&C	INPUTS			0	2	1JAN82	1FEB84	1FEB82	1MAR84	0 25
	PRECEDES	311711	311721				1	26	2	27	
311612	GT,ST,CC AND INDUS P&C	INPUTS			0	2	1JAN82	1MAR83	1FEB82	1APR83	0 14
	PRECEDES	311712	311722				1	15	2	16	
C 311613	GT,ST,CC AND INDUS P&C	INPUTS			0	2	1JAN82	1JAN82	1FEB82	1FEB82	0 0
	PRECEDES	311713	311723				1	1	2	2	
311711	CONCEPTUAL DESIGNS AND	REVISIONS			0	4	1MAR82	1APR84	1JUN82	1JUL84	0 25
	PRECEDES	311721	311731				3	28	6	31	
311712	CONCEPTUAL DESIGN AND	REVISIONS			0	6	1MAR82	1MAY83	1AUG82	1OCT83	0 14
	PRECEDES	311722	311732				3	17	8	22	
C 311713	CONCEPTUAL DESIGN AND	REVISIONS			0	10	1MAR82	1MAR82	1DEC82	1DEC82	0 0
	PRECEDES	311723	311733				3	3	12	12	
311721	CONCEPTUAL P AND C	APPROX AND ITERATIONS			0	4	1MAR82	1APR84	1JUN82	1JUL84	0 25
	PRECEDES	311731					3	28	6	31	
311722	CONCEPTUAL P&C	APPROX AND ITERATIONS			0	6	1MAR82	1MAY83	1AUG82	1OCT83	0 14
	PRECEDES	311732					3	17	8	22	
C 311723	CONCEPTUAL P&C	APPROX AND ITERATIONS			0	10	1MAR82	1MAR82	1DEC82	1DEC82	0 0
	PRECEDES	311733					3	3	12	12	
311731	CRITICAL CONCEPTUAL	DESIGN REVIEW			0	3	1JUL82	1AUG84	1SEP82	1OCT84	0 25
	PRECEDES	311811					7	32	9	34	
311732	CRITICAL CONCEPTUAL	DESIGN REVIEW			0	3	1SEP82	1NOV83	1NOV82	1JAN84	0 14
	PRECEDES	311812					9	23	11	25	
C 311733	CRITICAL CONCEPTUAL	DESIGN REVIEW			0	3	1JAN83	1JAN83	1MAR83	1MAR83	0 0
	PRECEDES	311813					13	13	15	15	
311811	UPGRADED DESIGNS,P&C	CALCS			0	2	1OCT82	1NOV84	1NOV82	1DEC84	0 25
	PRECEDES	311911	312111				10	35	11	36	
311812	UPGRADED DESIGNS,P&C	CALCS			0	2	1DEC82	1FEB84	1JAN83	1MAR84	0 14
	PRECEDES	311912	312112				12	26	13	27	

TABLE I - Continued.

SORT NODES										PAGE 3	
MODE=0/F											
ACTIVITY	DESCRIPTION				CODE	DURATION	START		FINISH		FF TF
							EARLY	LATE	EARLY	LATE	
C 311813	UPGRADED DESIGNS,P&C CALCS				0	2	1APR83	1APR83	1MAY83	1MAY83	0 0
	PRECEDES	311913	312113				16	16	17	17	
311911	EVAL BY INDUS ORG, NASA, DOE ETC				0	2	1DEC82	1JAN85	1JAN83	1FEB85	0 25
	PRECEDES	311921	318221				12	37	13	38	
311912	EVAL BY INDUS ORG, NASA, DOE ETC				0	2	1FEB83	1APR84	1MAR83	1MAY84	0 14
	PRECEDES	311922	318222				14	28	15	29	
C 311913	EVAL BY INDUS ORG, NASA, DOE ETC				0	2	1JUN83	1JUN83	1JUL83	1JUL83	0 0
	PRECEDES	311923	318223				18	18	19	19	
311921	CATEC PROG DP				0		EVENT		1JAN83	1FEB85	25
	PRECEDES	312111	315111	315211	315311				13	38	
		315611	315711	315811	315911						
		316111	316211	316311	316411						
		316511	316611	316711	316811						
		316911									
311922	CATEC PROG DP				0		EVENT		1MAR83	1MAY84	14
	PRECEDES	312112	315112	315212	315312				15	29	
		315612	315712	315812	315912						
		316112	316212	316312	316412						
		316512	316612	316712	316812						
		316912									
C 311923	CATEC PROG DP				0		EVENT		1JUL83	1JUL83	0
	PRECEDES	312113	315113	315213	315313				19	19	
		315613	315713	315813	315913						
		316113	316213	316313	316413						
		316513	316613	316713	316813						
		316913									
312111	INTEG ANAL MODELING,PARAMETRIC CALCS,COMP. SEL.				0	3	1FEB83	1MAR85	1APR83	1MAY85	0 25
	PRECEDES	312311					14	39	16	41	
312112	INTEG ANAL MODELING,PARAMETRIC CALCS,COMP. SEL.				0	3	1APR83	1JUN84	1JUN83	1AUG84	0 14
	PRECEDES	312312					16	30	18	32	
C 312113	INTEG ANAL MODELING,PARAMETRIC CALCS,COMP. SEL.				0	3	1AUG83	1AUG83	1OCT83	1OCT83	0 0
	PRECEDES	312313					20	20	22	22	
312311	PROTO TEC DES & FAB MODIF				0	6	1FEB83	1MAR85	1JUL83	1AUG85	0 25
	PRECEDES	312321	312411	313111			14	39	19	44	
312312	PROTO TEC DES & FAB MODIF				0	6	1APR83	1JUN84	1SEP83	1NOV84	0 14
	PRECEDES	312322	312412	313112			16	30	21	35	
C 312313	PROTO TEC DES & FAB MODIF				0	10	1AUG83	1AUG83	1MAY84	1MAY84	0 0
	PRECEDES	312323	312413	313113			20	20	29	29	

TABLE I - Continued.

SORT NODES											PAGE 4		
ACTIVITY	DESCRIPTION				MODE=0/F	CODE	DURATION	START		FINISH		FF	TF
								EARLY	LATE	EARLY	LATE		
	312321	P&L TESTS OF TEC MODULES				0	18	1AUG83	1MAY88	1JAN85	1OCT89	1	57
		PRECEDES	313111					20	77	37	94		
	312322	P&L TESTS OF TEC MODULES				0	18	1OCT83	1MAY88	1MAR85	1OCT89	1	55
		PRECEDES	313112					22	77	39	94		
	312323	P&L TESTS OF TEC MODULES				0	18	1JUN84	1MAY88	1NOV85	1OCT89	0	47
		PRECEDES	313113					30	77	47	94		
	312411	OVERALL CATEC APPL DESIGN				0	3	1APR83	1MAY85	1JUN83	1JUL85	0	25
		PRECEDES	312511	312611				16	41	18	43		
	312412	OVERALL CATEC APPL DESIGN				0	3	1JUN83	1AUG84	1AUG83	1OCT84	0	14
		PRECEDES	312512	312612				18	32	20	34		
C	312413	OVERALL CATEC APPL DESIGN				0	3	1OCT83	1OCT83	1DEC83	1DEC83	0	0
		PRECEDES	312513	312613				22	22	24	24		
	312511	CATEC APPL INTERACTIONS STUDIES				0	2	1JUL83	1AUG85	1AUG83	1SEP85	0	25
		PRECEDES	312611					19	44	20	45		
	312512	CATEC APPL INTERACTIONS STUDIES				0	2	1SEP83	1NOV84	1OCT83	1DEC84	0	14
		PRECEDES	312612					21	35	22	36		
C	312513	CATEC APPL INTERACTIONS STUDIES				0	2	1JAN84	1JAN84	1FEB84	1FEB84	0	0
		PRECEDES	312613					25	25	26	26		
	312611	DETAILED DWGS OF CATEC APPL DESIGNS				0	3	1SEP83	1OCT85	1NOV83	1DEC85	0	25
		PRECEDES	312711	312911	313111	313211		21	46	23	48		
	312612	DETAILED DWGS OF CATEC APPL DESIGNS				0	3	1NOV83	1JAN85	1JAN84	1MAR85	0	14
		PRECEDES	312712	312912	313112	313212		23	37	25	39		
C	312613	DETAILED DWGS OF CATEC APPL DESIGNS				0	3	1MAR84	1MAR84	1MAY84	1MAY84	0	0
		PRECEDES	312713	312913	313113	313213		27	27	29	29		
	312711	DETAILED EST OF COMPS, OVERALL P&L, MAINT NEEDS				0	3	1DEC83	1JAN86	1FEB84	1MAR86	0	25
		PRECEDES	312811	312911				24	49	26	51		
	312712	DETAILED EST OF COMPS, OVERALL P&L, MAINT NEEDS				0	3	1FEB84	1APR85	1APR84	1JUN85	0	14
		PRECEDES	312812	312912				26	40	28	42		
C	312713	DETAILED EST OF COMPS, OVERALL P&L, MAINT NEEDS				0	3	1JUN84	1JUN84	1AUG84	1AUG84	0	0
		PRECEDES	312813	312913				30	30	32	32		
	312811	DETAILED CATEC APPL COST ANALY				0	3	1DEC83	1MAR86	1FEB84	1MAY86	2	27
		PRECEDES	312911					24	51	26	53		
	312812	DETAILED CATEC APPL COST ANAL				0	3	1FEB84	1JUN85	1APR84	1AUG85	2	16
		PRECEDES	312912					26	42	28	44		

TABLE I - Continued.

TABLE I - Continued.										
ACTIVITY	DESCRIPTION	MODE=O/F	CODE	DURATION	START		FINISH		PAGE	
					EARLY	LATE	EARLY	LATE	FF	TF
312813	DETAILED CATEC APPL COST ANAL		0	3	1JUN84	1AUG84	1AUG84	1OCT84	2	2
	PRECEDES 312913				30	32	32	34		
312911	CATEC APPL DESIGN REVIEW AND REFINE		0	2	1MAR84	1APR86	1APR84	1MAY86	0	25
	PRECEDES 313211				27	52	28	53		
312912	CATEC APPL DESIGN REVIEW AND REFINE		0	2	1MAY84	1JUL85	1JUN84	1AUG85	0	14
	PRECEDES 313212				29	43	30	44		
C 312913	CATEC APPL DESIGN REVIEW AND REFINE		0	2	1SEP84	1SEP84	1OCT84	1OCT84	0	0
	PRECEDES 313213				33	33	34	34		
313111	D AND F OF TEC PROTOTYPES		0	4	1DEC83	1AUG88	1MAR84	1NOV88	0	56
	PRECEDES 313121 313131				24	80	27	83		
313112	D AND F OF TEC PROTOTYPES		0	4	1FEB84	1AUG88	1MAY84	1NOV88	0	54
	PRECEDES 313122 313132				26	80	29	83		
313113	D AND F OF TEC PROTOTYPES		0	4	1SEP84	1AUG88	1DEC84	1NOV88	0	47
	PRECEDES 313123 313133				33	80	36	83		
313121	INTEG ADAPS, FACILS, INSTRS, & CTRL INSTALL		0	4	1DEC83	1AUG88	1MAR84	1NOV88	0	56
	PRECEDES 313131				24	80	27	83		
313122	INTEG ADAPS, FACILS, INSTRS, & CTRL INSTALL		0	4	1FEB84	1AUG88	1MAY84	1NOV88	0	54
	PRECEDES 313132				26	80	29	83		
313123	INTEG ADAPS, FACILS, INSTRS, & CTRL INSTALL		0	4	1SEP84	1AUG88	1DEC84	1NOV88	0	47
	PRECEDES 313133				33	80	36	83		
313131	INTEG PROTO TESTG(DOE CONTROL)		0	12	1APR84	1DEC88	1MAR85	1NOV89	56	56
	SINK ACTIVITY				28	84	39	95		
313132	INTEG PROTO TESTG(DOE CONTROL)		0	12	1JUN84	1DEC88	1MAY85	1NOV89	54	54
	SINK ACTIVITY				30	84	41	95		
313133	INTEG PROTO TESTG(DOE CONTROL)		0	12	1JAN85	1DEC88	1DEC85	1NOV89	47	47
	SINK ACTIVITY				37	84	48	95		
313211	CATEC SEGMENT DESIGN AND FACIL IDENT		0	3	1MAY84	1JUN86	1JUL84	1AUG86	0	25
	PRECEDES 313311 313411				29	54	31	56		
313212	CATEC SEGMENT DESIGN AND FACIL INDENT		0	3	1JUL84	1SEP85	1SEP84	1NOV85	0	14
	PRECEDES 313312 313412				31	45	33	47		
C 313213	CATEC SEGMENT DESIGN AND FACIL INDENT		0	3	1NOV84	1NOV84	1JAN85	1JAN85	0	0
	PRECEDES 313313 313413				35	35	37	37		
313311	CATEC SEG FAB		0	5	1JUN84	1SEP86	1OCT84	1JAN87	2	27
	PRECEDES 313511				30	57	34	61		

TABLE I - Continued.

SORT NODES											PAGE 6
MODE=0/F											
ACTIVITY	DESCRIPTION				CODE	DURATION	START		FINISH		FF TF
							EARLY	LATE	EARLY	LATE	
313312	CATEC SEG FAB				0	6	1AUG84	1FEB86	1JAN85	1JUL86	4 18
	PRECEDES	313512					32	50	37	55	
313313	CATEC SEG FAB				0	12	1DEC84	1FEB85	1NOV85	1JAN86	2 2
	PRECEDES	313513					36	38	47	49	
313411	CATEC SEG FAC ADAP				0	5	1AUG84	1SEP86	1DEC84	1JAN87	0 25
	PRECEDES	313511					32	57	36	61	
313412	CATEC SEG FAC ADAP				0	8	1OCT84	1DEC85	1MAY85	1JUL86	0 14
	PRECEDES	313512					34	48	41	55	
C 313413	CATEC SEG FAC ADAP				0	12	1FEB85	1FEB85	1JAN86	1JAN86	0 0
	PRECEDES	313513					38	38	49	49	
313511	CATEC SEG INSTAL AND INSTRN			313911	0	3	1JAN85	1FEB87	1MAR85	1APR87	0 25
	PRECEDES	313611	313811				37	62	39	64	
313512	CATEC SEG INSTAL AND INSTRN			313912	0	3	1JUN85	1AUG86	1AUG85	1OCT86	0 14
	PRECEDES	313612	313812				42	56	44	58	
C 313513	CATEC SEG INSTAL AND INSTRN			313913	0	3	1FEB86	1FEB86	1APR86	1APR86	0 0
	PRECEDES	313613	313813				50	50	52	52	
313611	CATEC SEG SHAKEDOWNS,MODIF			313911	0	2	1APR85	1MAY87	1MAY85	1JUN87	0 25
	PRECEDES	313711	313811				40	65	41	66	
313612	CATEC SEG SHAKEDOWNS,MODIF			313912	0	2	1SEP85	1NOV86	1OCT85	1DEC86	0 14
	PRECEDES	313712	313812				45	59	46	60	
C 313613	CATEC SEG SHAKEDOWNS,MODIF			313913	0	2	1MAY86	1MAY86	1JUN86	1JUN86	0 0
	PRECEDES	313713	313813				53	53	54	54	
313711	CATEC SEG PERF MAPPING				0	3	1JUN85	1JUL87	1AUG85	1SEP87	0 25
	PRECEDES	314111					42	67	44	69	
313712	CATEC SEG PERF MAPPING				0	3	1NOV85	1JAN87	1JAN86	1MAR87	0 14
	PRECEDES	314112					47	61	49	63	
C 313713	CATEC SEG PERF MAPPING				0	3	1JUL86	1JUL86	1SEP86	1SEP86	0 0
	PRECEDES	314113					55	55	57	57	
313811	CATEC SEGMENT P&L TESTS				0	18	1APR85	1JUN88	1SEP86	1NOV89	38 38
	SINK ACTIVITY						40	78	57	95	
313812	CATEC SEGMENT P&L TESTS				0	18	1SEP85	1JUN88	1FEB87	1NOV89	33 33
	SINK ACTIVITY						45	78	62	95	
313813	CATEC SEGMENT P&L TESTS				0	18	1MAY86	1JUN88	1OCT87	1NOV89	25 25
	SINK ACTIVITY						53	78	70	95	

TABLE I - Continued.

SORT MODES												PAGE 7	
ACTIVITY	DESCRIPTION				MODE=0/F	CODE	DURATION	START		FINISH		FF	TF
								EARLY	LATE	EARLY	LATE		
	313911	CATEC SEG EVAL, REFINE, RERUNS & REPORTS SINK ACTIVITY				0	18	1JUN85 42	1JUN88 78	1NOV86 59	1NOV89 95	36	36
	313912	CATEC SEG EVAL, REFINE, RERUNS & REPORTS SINK ACTIVITY				0	18	1NOV85 47	1JUN88 78	1APR87 64	1NOV89 95	31	31
	313913	CATEC SEG EVAL, REFINE, RERUNS & REPORTS SINK ACTIVITY				0	18	1JUL86 55	1JUN88 78	1DEC87 72	1NOV89 95	23	23
	314111	IDENT TEST FACIL & MODIF OF CATEC DESIGNS PRECEDES 314211 314311				0	2	1JUN85 42	1JUL87 67	1JUL85 43	1AUG87 68	0	25
	314112	IDENT TEST FACIL & MODIF OF CATEC DESIGNS PRECEDES 314212 314312				0	2	1NOV85 47	1JAN87 61	1DEC85 48	1FEB87 62	0	14
C	314113	IDENT TEST FACIL & MODIF OF CATEC DESIGNS PRECEDES 314213 314313				0	2	1JUL86 55	1JUL86 55	1AUG86 56	1AUG86 56	0	0
	314211	CATEC FAB PRECEDES 314411				0	6	1AUG85 44	1SEP87 69	1JAN86 49	1FEB88 74	0	25
	314212	CATEC FAB PRECEDES 314412				0	12	1JAN86 49	1MAR87 63	1DEC86 60	1FEB88 74	0	14
C	314213	CATEC FAB PRECEDES 314413				0	18	1SEP86 57	1SEP86 57	1FEB88 74	1FEB88 74	0	0
	314311	CATEC FACIL ADAP PRECEDES 314411				0	6	1AUG85 44	1SEP87 69	1JAN86 49	1FEB88 74	0	25
	314312	CATEC FACIL ADAP PRECEDES 314412				0	12	1JAN86 49	1MAR87 63	1DEC86 60	1FEB88 74	0	14
C	314313	CATEC FACIL ADAP PRECEDES 314413				0	18	1SEP86 57	1SEP86 57	1FEB88 74	1FEB88 74	0	0
	314411	CATEC INSTAL & INSTR PRECEDES 314511 314711 314811				0	3	1FEB86 50	1MAR88 75	1APR86 52	1MAY88 77	0	25
	314412	CATEC INSTAL & INSTR PRECEDES 314512 314712 314812				0	3	1JAN87 61	1MAR88 75	1MAR87 63	1MAY88 77	0	14
C	314413	CATEC INSTAL & INSTR PRECEDES 314513 314713 314813				0	3	1MAR88 75	1MAR88 75	1MAY88 77	1MAY88 77	0	0
	314511	CATEC SHAKEDOWNS & MODIF PRECEDES 314611 314711				0	2	1MAY86 53	1JUN88 78	1JUN86 54	1JUL88 79	0	25
	314512	CATEC SHAKEDOWNS & MODIF PRECEDES 314612 314712				0	2	1APR87 64	1JUN88 78	1MAY87 65	1JUL88 79	0	14

TABLE I - Continued.

PAGE 8										
SORT NODES										
MODE=0/F										
ACTIVITY	DESCRIPTION			CODE	DURATION	START		FINISH		FF TF
						EARLY	LATE	EARLY	LATE	
C 314513	CATEC SHAKEDOWNS & MODIF			0	2	1JUN88	1JUN88	1JUL88	1JUL88	0 0
	PRECEDES	314613	314713			78	78	79	79	
314611	CATEC PERF MAPPING			0	3	1JUL86	1SEP89	1SEP86	1NOV89	38 38
	SINK ACTIVITY					55	93	57	95	
314612	CATEC PERF MAPPING			0	3	1JUN87	1SEP89	1AUG87	1NOV89	27 27
	SINK ACTIVITY					66	93	68	95	
314613	CATEC PERF MAPPING			0	3	1AUG88	1SEP89	1OCT88	1NOV89	13 13
	SINK ACTIVITY					80	93	82	95	
314711	CATEC PERF. VERIF & LIFE ESTIM TESTS			0	18	1MAY86	1JUN88	1OCT87	1NOV89	25 25
	SINK ACTIVITY					53	78	70	95	
314712	CATEC PERF. VERIF & LIFE ESTIM TESTS			0	18	1APR87	1JUN88	1SEP88	1NOV89	14 14
	SINK ACTIVITY					64	78	81	95	
C 314713	CATEC PERF. VERIF & LIFE ESTIM TESTS			0	18	1JUN88	1JUN88	1NOV89	1NOV89	0 0
	SINK ACTIVITY					78	78	95	95	
314811	CATEC EVAL, REFINE, RERUNS & REPORTS			0	18	1MAY86	1JUN88	1OCT87	1NOV89	0 25
	PRECEDES	314911				53	78	70	95	
314812	CATEC EVAL, REFINE, RERUNS & REPORTS			0	18	1APR87	1JUN88	1SEP88	1NOV89	0 14
	PRECEDES	314912				64	78	81	95	
C 314813	CATEC EVAL, REFINE, RERUNS & REPORTS			0	18	1JUN88	1JUN88	1NOV89	1NOV89	0 0
	PRECEDES	314913				78	78	95	95	
314911	PUBLIC DEMO AND FED			0		EVENT		1APR86	1NOV89	43
	SINK ACTIVITY							52	95	
314912	PUBLIC DEMO AND FED			0		EVENT		1MAR87	1NOV89	32
	SINK ACTIVITY							63	95	
314913	PUBLIC DEMO AND FED			0		EVENT		1MAY88	1NOV89	18
	SINK ACTIVITY							77	95	
315111	PROTECTIVE CLAD E&D(PILOT LINE)			0	18	1FEB83	1JUN86	1JUL84	1NOV87	0 40
	PRECEDES	315121	315411			14	54	31	71	
315112	PROTECTIVE CLAD E&D(PILOT LINE)			0	18	1APR83	1JUN86	1SEP84	1NOV87	0 38
	PRECEDES	315122	315412			16	54	33	71	
315113	PROTECTIVE CLAD E&D(PILOT LINE)			0	18	1AUG83	1JUN86	1JAN85	1NOV87	0 34
	PRECEDES	315123	315413			20	54	37	71	
315121	PROTECTIVE CLAD E&D(PRODUCTION LINE)			0	24	1AUG84	1DEC87	1JUL86	1NOV89	40 40
	SINK ACTIVITY					32	72	55	95	

TABLE I - Continued.

PAGE 9									
SORT NODES									
MODE=0/F									
ACTIVITY	DESCRIPTION	CODE	DURATION	START EARLY	START LATE	FINISH EARLY	FINISH LATE	FF	TF
315122	PROTECTIVE CLAD E&D(PRODUCTION LINE) SINK ACTIVITY	0	24	1OCT84 34	1DEC87 72	1SEP86 57	1NOV89 95	38	38
315123	PROTECTIVE CLAD E&D(PRODUCTION LINE) SINK ACTIVITY	0	24	1FEB85 38	1DEC87 72	1JAN87 61	1NOV89 95	34	34
315211	RESERVOIR E&D SINK ACTIVITY	0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64
315212	RESERVOIR E&D SINK ACTIVITY	0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56
315213	RESERVOIR E&D SINK ACTIVITY	0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46
315311	HP COMPONENTS E AND D SINK ACTIVITY	0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64
315312	HP COMPONENTS E AND D SINK ACTIVITY	0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56
315313	HP COMPONENTS E AND D SINK ACTIVITY	0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46
315411	TEC HP FAB AND ASSLY PRECEDES 315511	0	18	1AUG83 20	1DEC87 72	1JAN85 37	1MAY89 89	0	52
315412	TEC HP FAB AND ASSLY PRECEDES 315512	0	24	1OCT83 22	1JUN87 66	1SEP85 45	1MAY89 89	0	44
315413	TEC HP FAB AND ASSLY PRECEDES 315513	0	30	1FEB84 26	1DEC86 60	1JUL86 55	1MAY89 89	0	34
315511	TEC HP PROCESSING AND TESTING SINK ACTIVITY	0	18	1FEB84 26	1JUN88 78	1JUL85 43	1NOV89 95	52	52
315512	TEC HP PROCESSING AND TESTING SINK ACTIVITY	0	24	1APR84 28	1DEC87 72	1MAR86 51	1NOV89 95	44	44
315513	TEC HP PROCESSING AND TESTING SINK ACTIVITY	0	30	1AUG84 32	1JUN87 66	1JAN87 61	1NOV89 95	34	34
315611	COMBUSTOR E&D SINK ACTIVITY	0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64
315612	COMBUSTOR E & D SINK ACTIVITY	0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56
315613	COMBUSTOR E & D SINK ACTIVITY	0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46

TABLE I - Continued.

PAGE 10										
SORT NODES										
MODE=0/F										
ACTIVITY	DESCRIPTION	CODE	DURATION	START EARLY	START LATE	FINISH EARLY	FINISH LATE	FF	TF	
315711	CATEC FAB, ASSLY, INTEGRITY CHECKS SINK ACTIVITY	0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64	
315712	CATEC FAB, ASSLY, INTEGRITY CHECKS SINK ACTIVITY	0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56	
315713	CATEC FAB, ASSLY, INTEGRITY CHECKS SINK ACTIVITY	0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46	
315811	CATEC INSTR, CONTROLS, SAFETY E&D SINK ACTIVITY	0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64	
315812	CATEC INSTR, CONTROLS, SAFETY E&D SINK ACTIVITY	0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56	
315813	CATEC INSTR, CONTROLS, SAFETY E&D SINK ACTIVITY	0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46	
315911	SYS INTEG E&D AND ANAL MODELING SINK ACTIVITY	0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64	
315912	SYS INTEG E&D AND ANAL MODELING SINK ACTIVITY	0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56	
315913	SYS INTEG E&D AND ANAL MODELING SINK ACTIVITY	0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46	
316111	NON-TEC CONVERSION SYSTEMS E&D SINK ACTIVITY	0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64	
316112	NON-TEC CONVERSION SYSTEMS E&D SINK ACTIVITY	0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56	
316113	NON-TEC CONVERSION SYSTEMS E&D SINK ACTIVITY	0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46	
316211	POWER CONDITIONING SYSTEMS E&D SINK ACTIVITY	0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64	
316212	POWER CONDITIONING SYSTEMS E&D SINK ACTIVITY	0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56	
316213	POWER CONDITIONING SYSTEMS E&D SINK ACTIVITY	0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46	
316311	POLLUTION CONTROL SYSTEMS E&D SINK ACTIVITY	0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64	
316312	POLLUTION CONTROL SYSTEMS E&D SINK ACTIVITY	0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56	

TABLE I - Continued.

PAGE 11										
SORT NODES										
ACTIVITY	DESCRIPTION	MODE=0/F	CODE	DURATION	START		FINISH		FF	TF
					EARLY	LATE	EARLY	LATE		
316313	POLLUTION CONTROL SYSTEMS E&D SINK ACTIVITY		0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46
316411	FUEL SYSTEMS E&D SINK ACTIVITY		0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64
316412	FUEL SYSTEMS E&D SINK ACTIVITY		0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56
316413	FUEL SYSTEMS E&D SINK ACTIVITY		0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46
316511	HEAT EXCH E&D SINK ACTIVITY		0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64
316512	HEAT EXCH E&D SINK ACTIVITY		0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56
316513	HEAT EXCH E&D SINK ACTIVITY		0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46
316611	I/F SYSTEMS E&D SINK ACTIVITY		0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64
316612	I/F SYSTEMS E&D SINK ACTIVITY		0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56
316613	I/F SYSTEMS E&D SINK ACTIVITY		0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46
316711	PROCESS INSTR, CNTRLs, SAFETY E&D SINK ACTIVITY		0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64
316712	PROCESS INSTR, CNTRLs, SAFETY E&D SINK ACTIVITY		0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56
316713	PROCESS INSTR, CNTRLs, SAFETY E&D SINK ACTIVITY		0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46
316811	SYS INTG E&D & ANAL MODELING SINK ACTIVITY		0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64
316812	SYS INTG E&D & ANAL MODELING SINK ACTIVITY		0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56
316813	SYS INTG E&D & ANAL MODELING SINK ACTIVITY		0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46
316911	AUX SYS TESTING & MODIF SINK ACTIVITY		0	18	1FEB83 14	1JUN88 78	1JUL84 31	1NOV89 95	64	64

TABLE I - Concluded.

PAGE 12									
SORT NODES									
MODE=0/F									
ACTIVITY	DESCRIPTION	CODE	DURATION	START EARLY	START LATE	FINISH EARLY	FINISH LATE	FF	TF
316912	AUX SYS TESTING & MODIF SINK ACTIVITY	0	24	1APR83 16	1DEC87 72	1MAR85 39	1NOV89 95	56	56
316913	AUX SYS TESTING & MODIF SINK ACTIVITY	0	30	1AUG83 20	1JUN87 66	1JAN86 49	1NOV89 95	46	46
317111	COMBUSTOR SPEC PRECEDES 311711	0	2	1JAN82 1	1FEB84 26	1FEB82 2	1MAR84 27	0	25
317112	COMBUSTOR SPEC PRECEDES 311712	0	2	1JAN82 1	1MAR83 15	1FEB82 2	1APR83 16	0	14
317113	COMBUSTOR SPEC PRECEDES 311713	0	2	1JAN82 1	1JAN82 1	1FEB82 2	1FEB82 2	0	0
318111	IMPACT IDENTIFICATION PRECEDES 311921	0	4	1JAN82 1	1NOV84 35	1APR82 4	1FEB85 38	9	34
318112	IMPACT IDENTIFICATION PRECEDES 311922	0	4	1JAN82 1	1FEB84 26	1APR82 4	1MAY84 29	11	25
318113	IMPACT IDENTIFICATION PRECEDES 311923	0	4	1JAN82 1	1APR83 16	1APR82 4	1JUL83 19	15	15
318211	PRELIM MARKET SURVEY PRECEDES 311911	0	4	1JAN82 1	1SEP84 33	1APR82 4	1DEC84 36	7	32
318212	PRELIM MARKET SURVEY PRECEDES 311912	0	4	1JAN82 1	1DEC83 24	1APR82 4	1MAR84 27	9	23
318213	PRELIM MARKET SURVEY PRECEDES 311913	0	4	1JAN82 1	1FEB83 14	1APR82 4	1MAY83 17	13	13
318221	MARKET ANALYSIS SINK ACTIVITY	0	12	1FEB83 14	1DEC88 84	1JAN84 25	1NOV89 95	70	70
318222	MARKET ANALYSIS SINK ACTIVITY	0	12	1APR83 16	1DEC88 84	1MAR84 27	1NOV89 95	68	68
318223	MARKET ANALYSIS SINK ACTIVITY	0	12	1AUG83 20	1DEC88 84	1JUL84 31	1NOV89 95	64	64

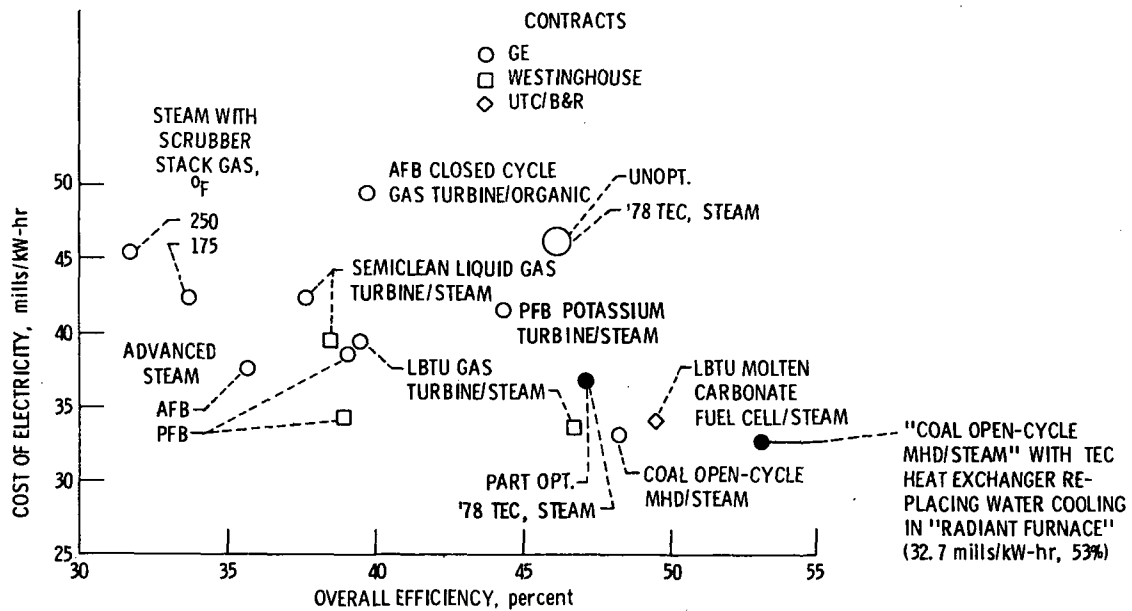


Figure 1. - ECAS Phase 2 results using 30-year levelized cost in mid-1975 dollars. Fuel cost assumed constant in fixed dollars.

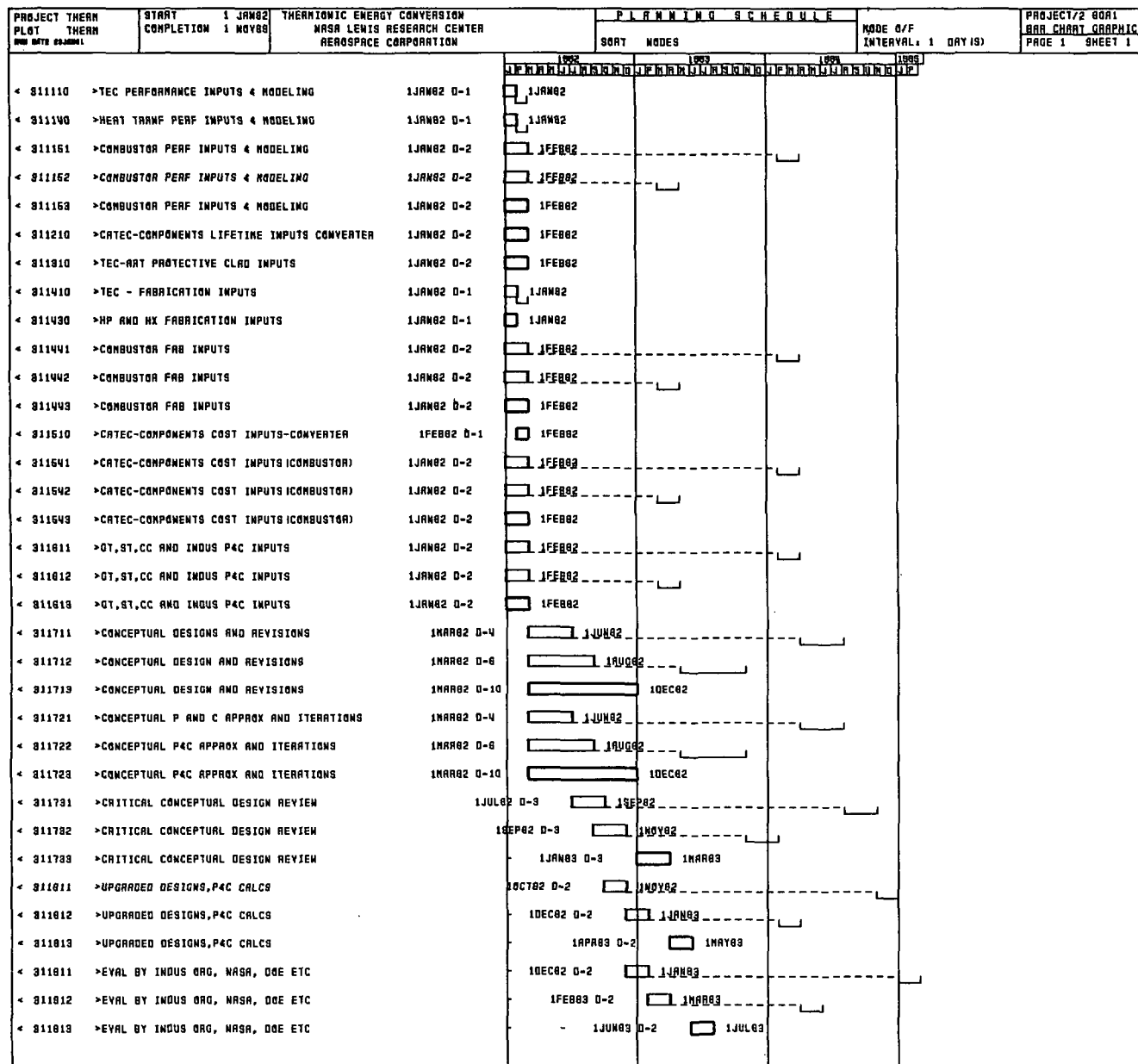


Figure 2

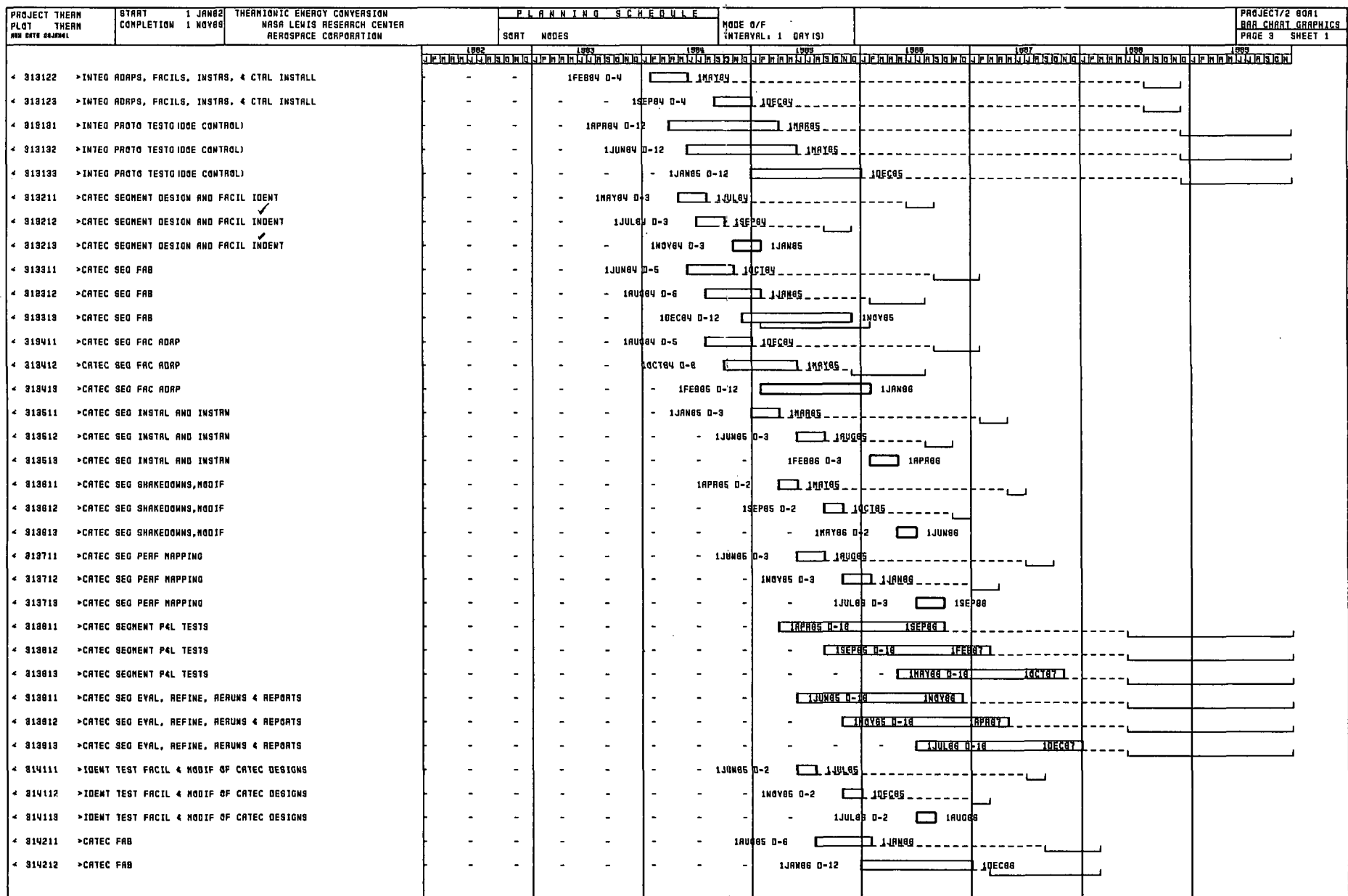


Figure 2. - Continued.

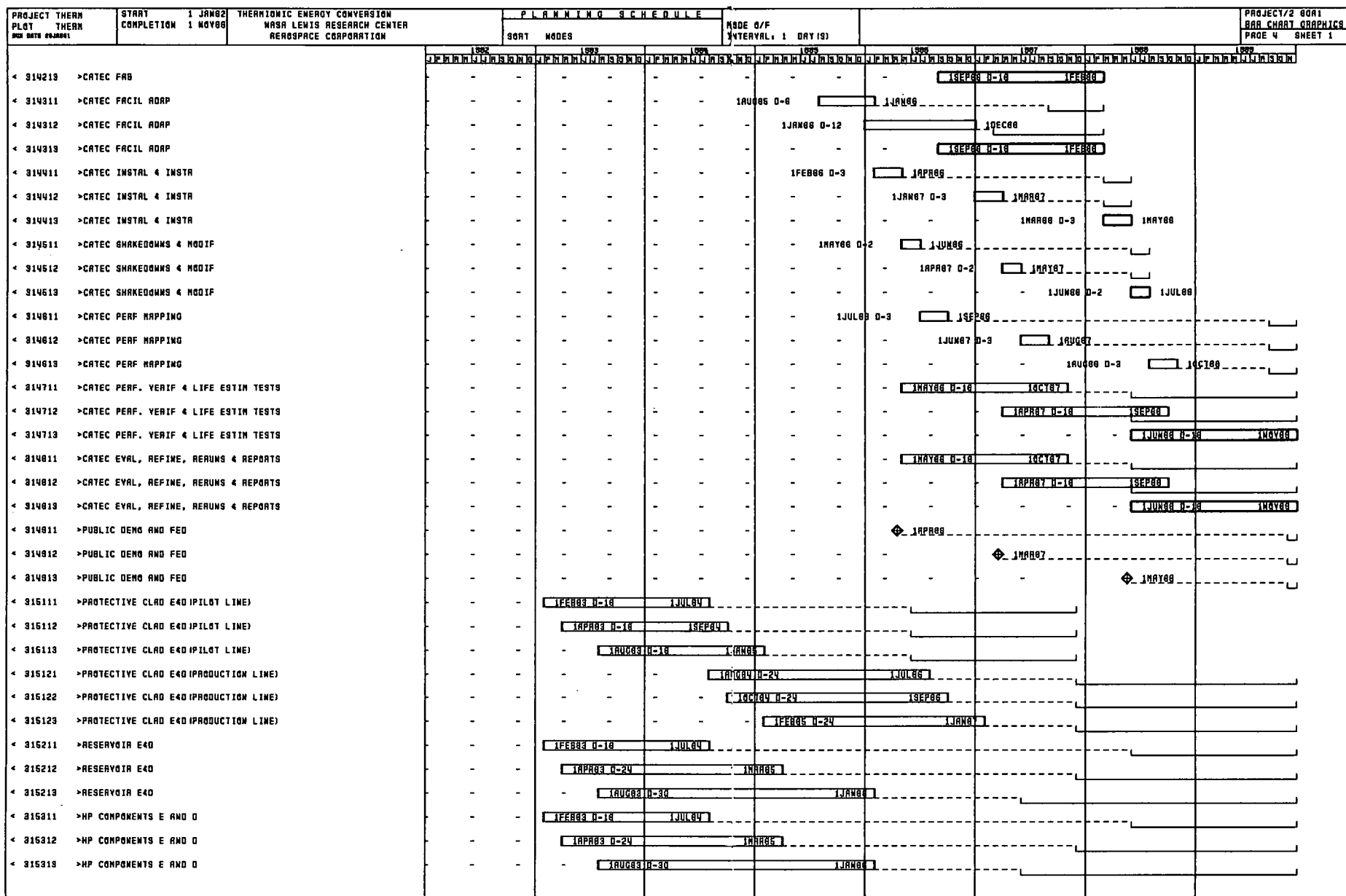


Figure 2 - Continued.

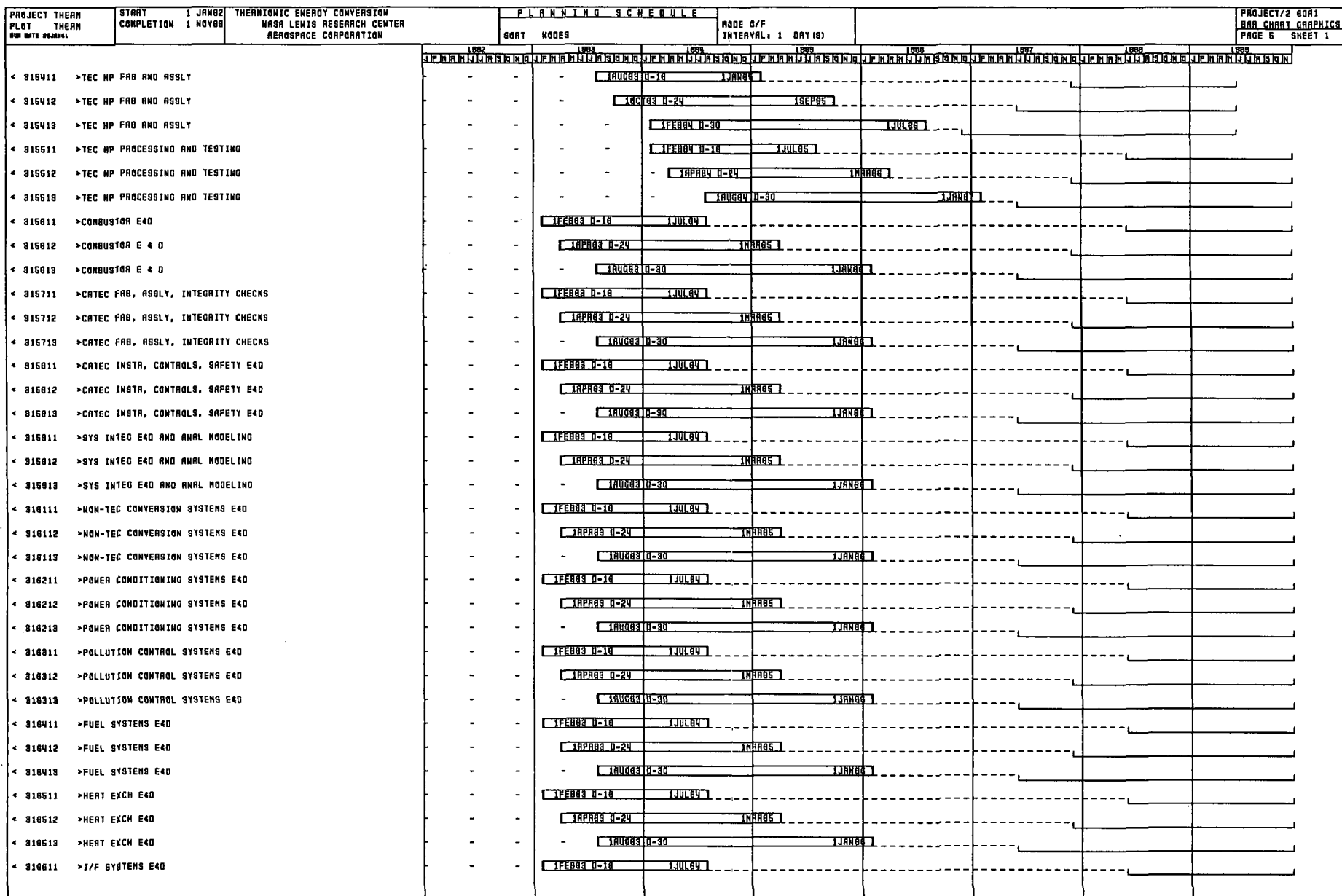


Figure 2. - Continued

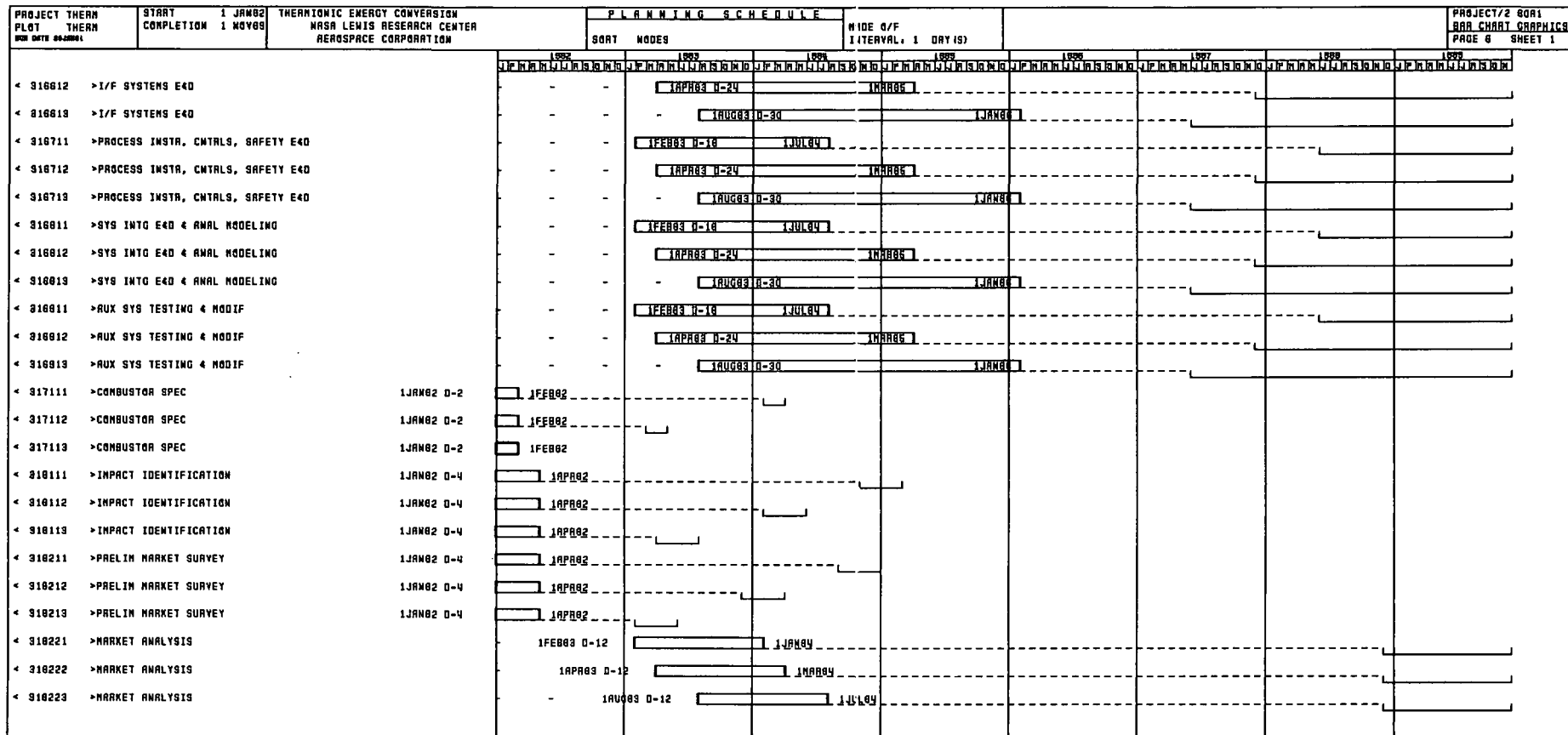


Figure 2. - Concluded.

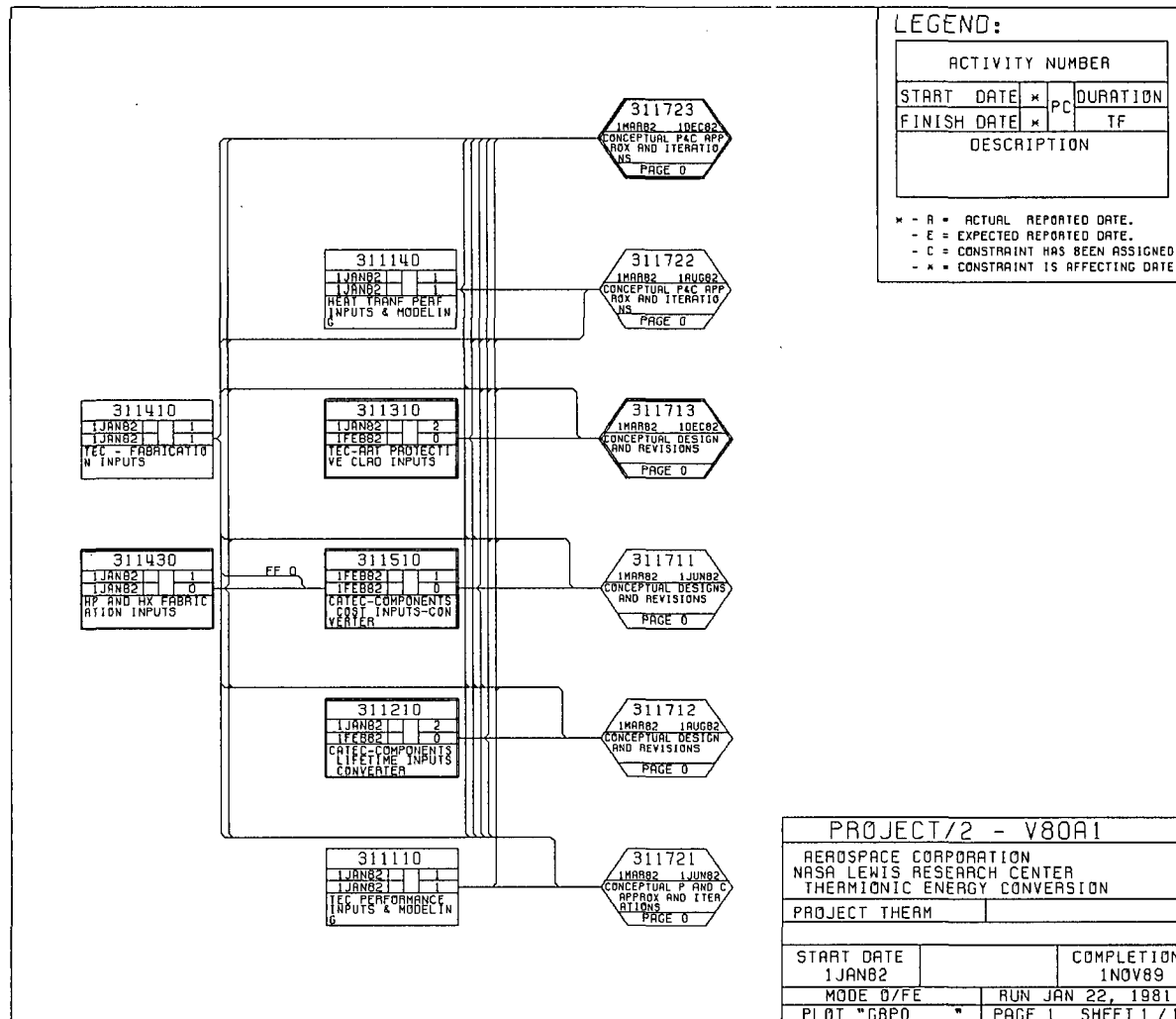


Figure 3(a).

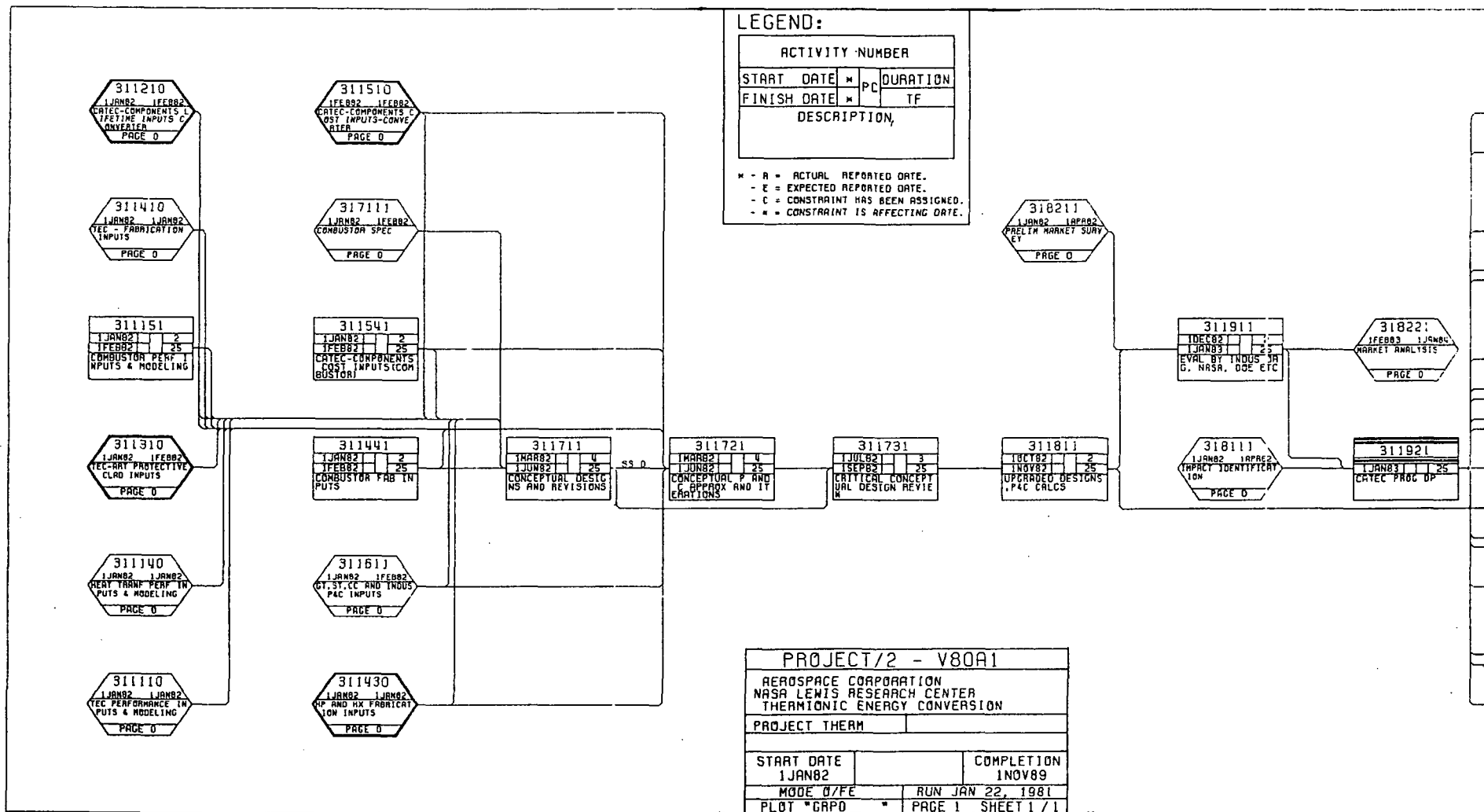


Figure 3(b). - Phase L

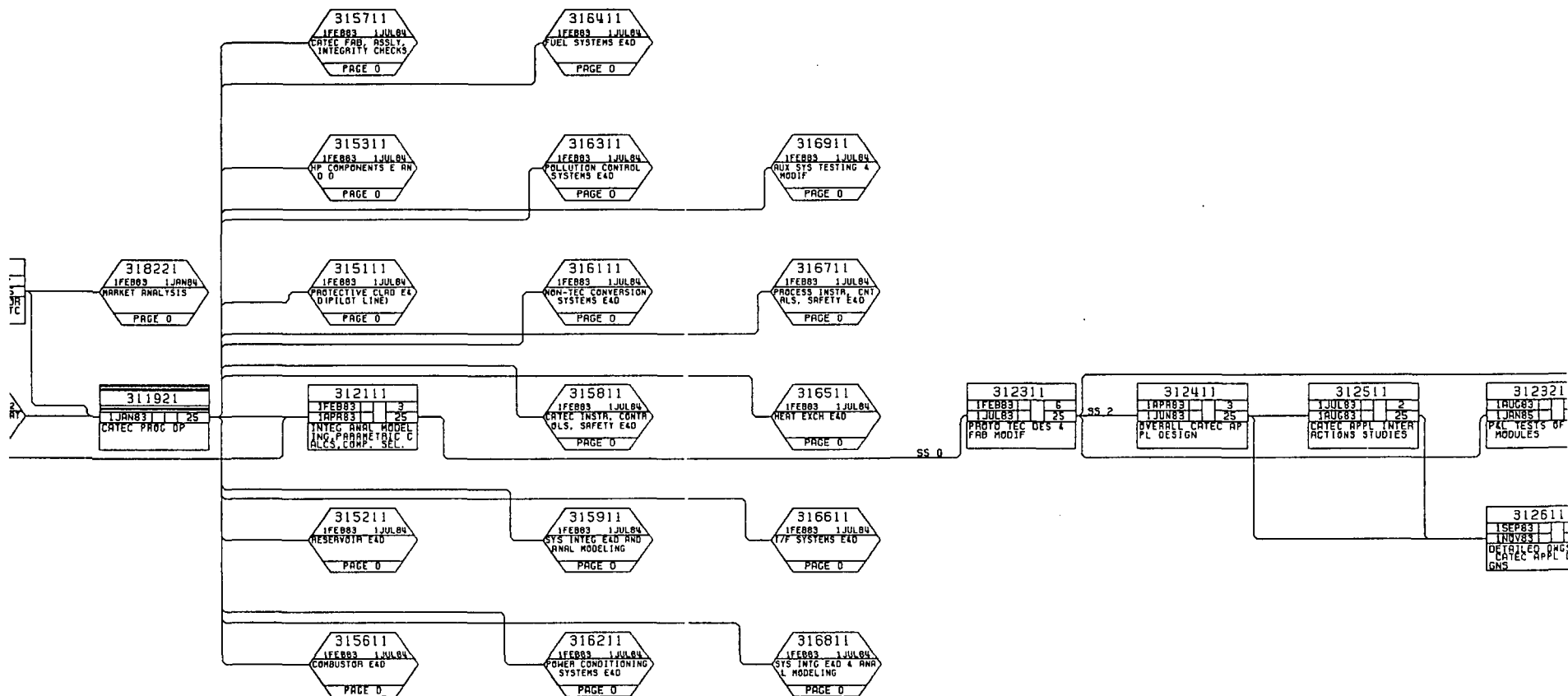


Figure 3(b). - Continued.

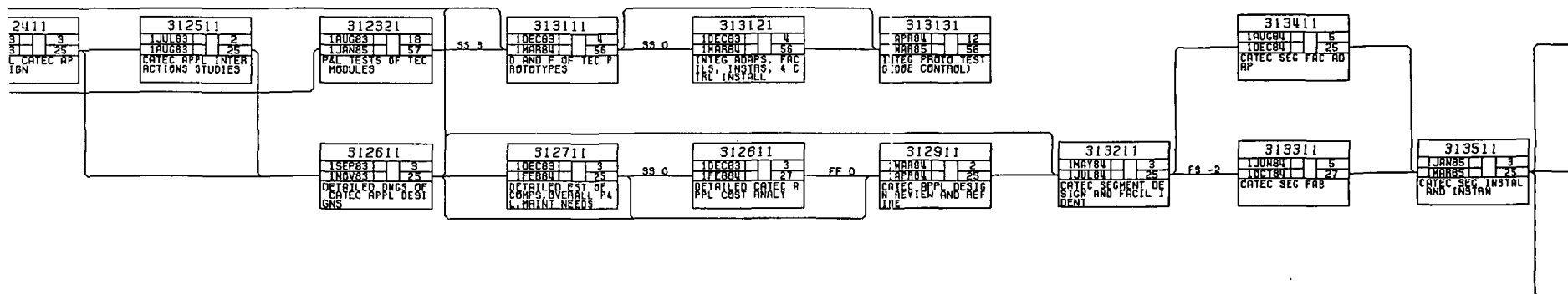


Figure 3(b). - Continued.

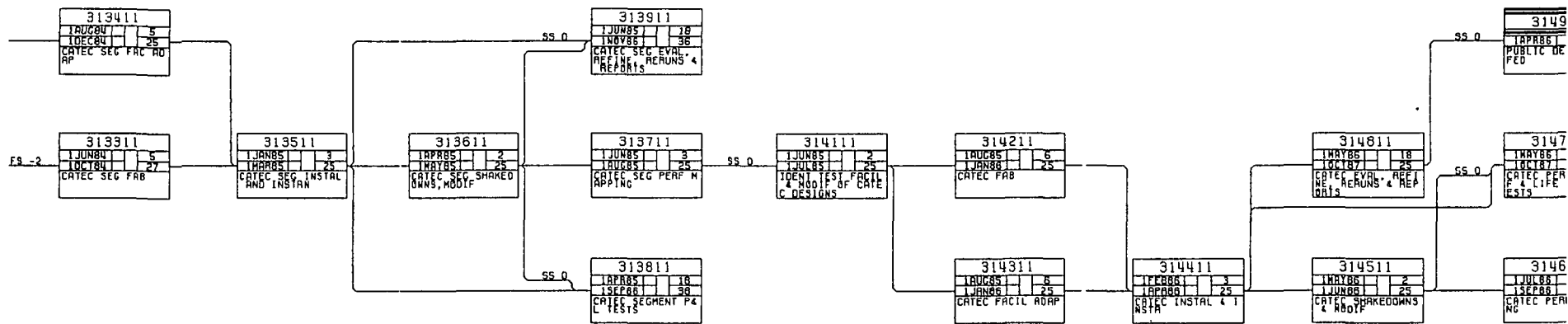


Figure 3(b). - Continued.

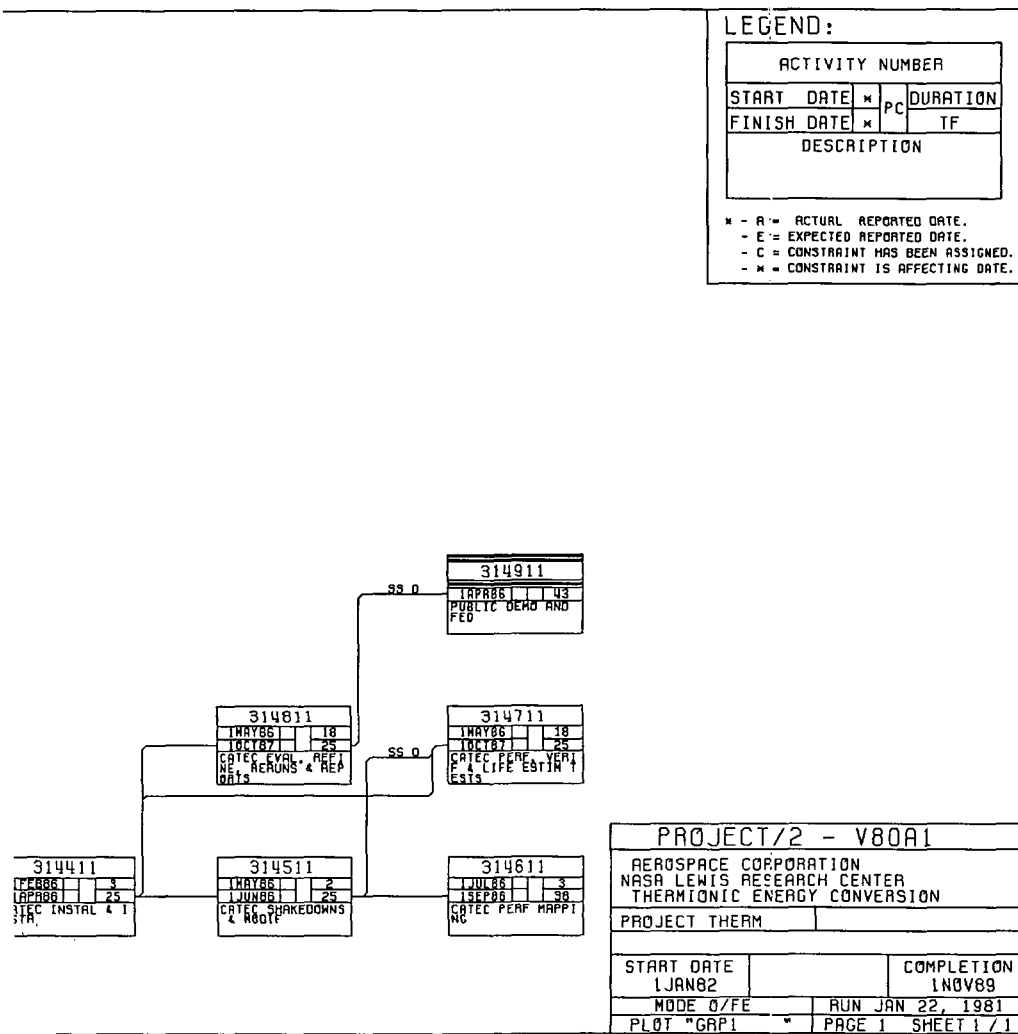


Figure 3(b). - Concluded.

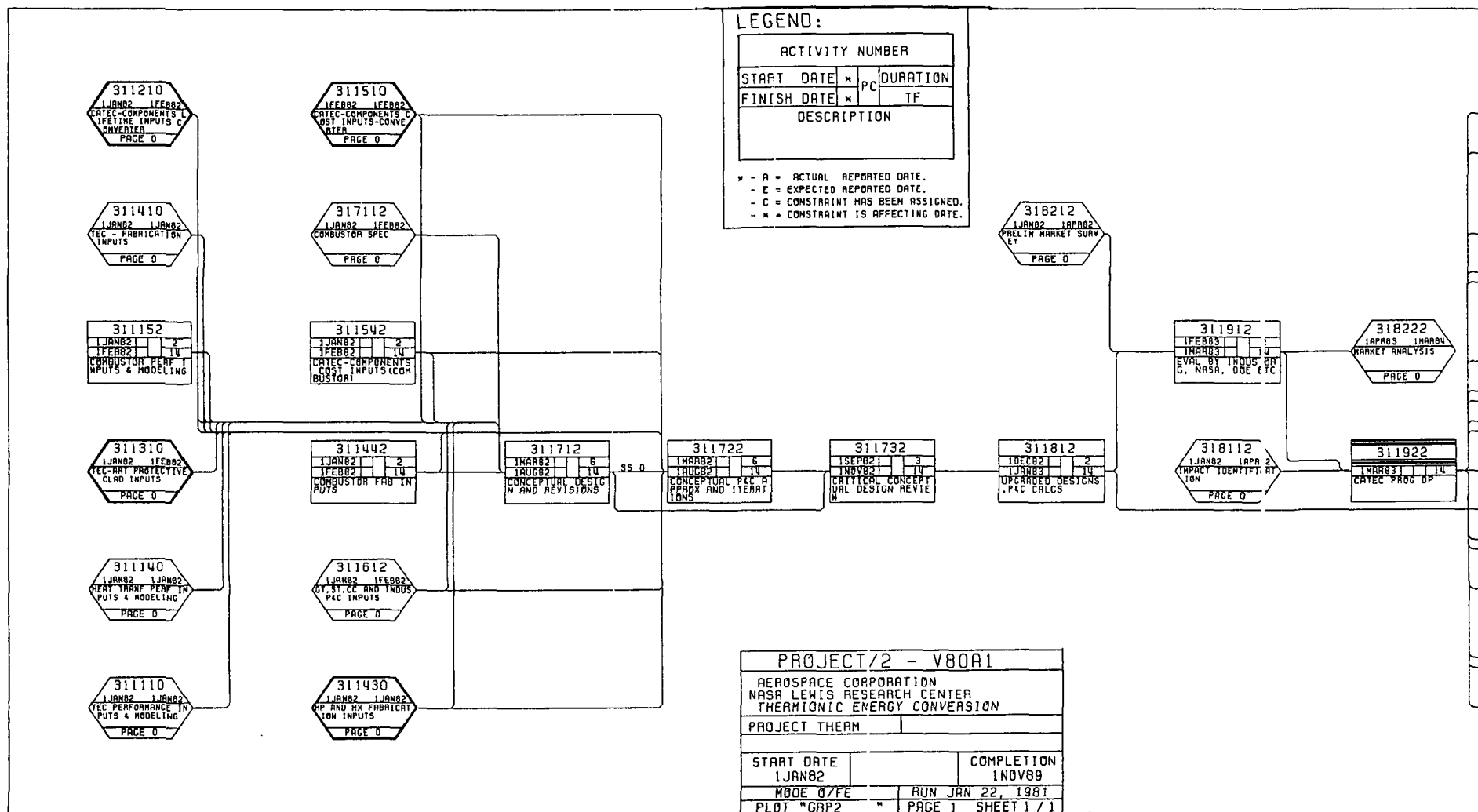


Figure 3(c). - Phase 2.

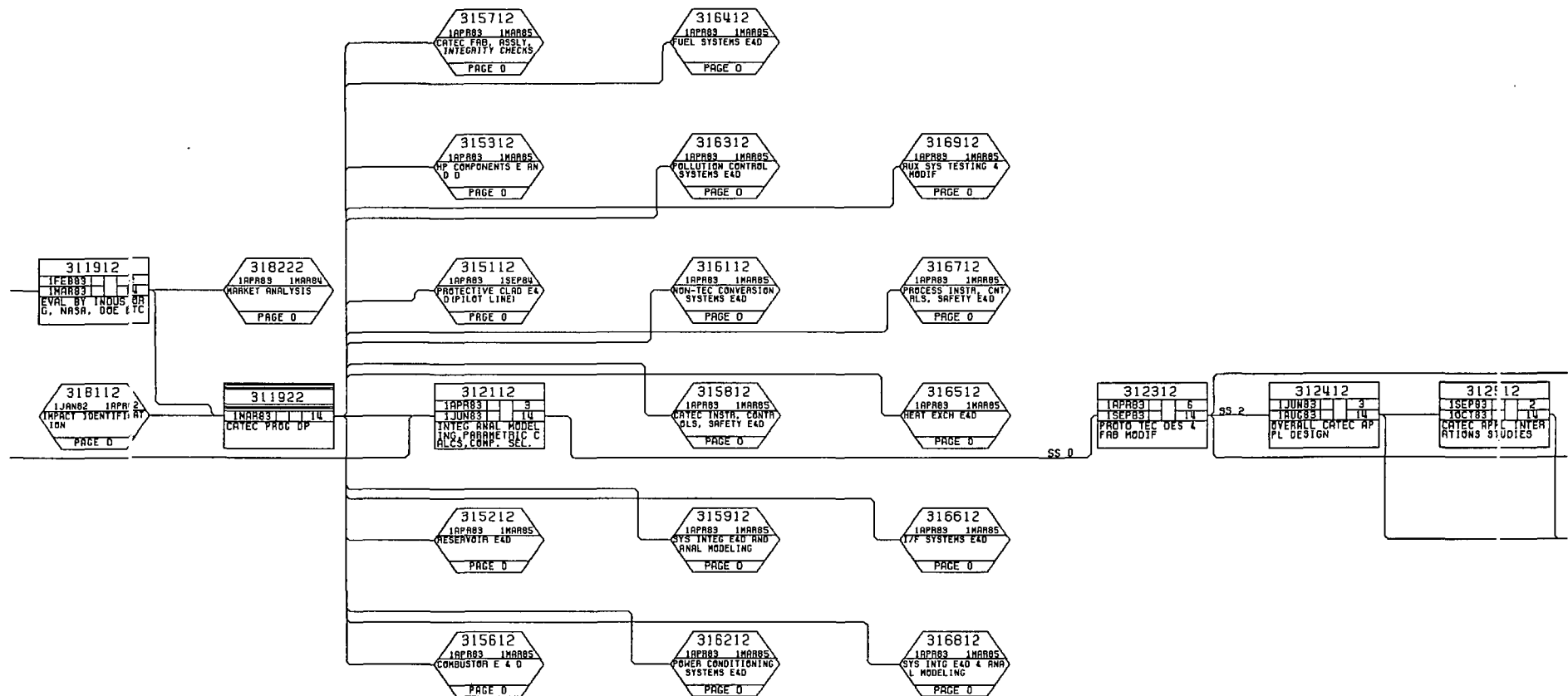


Figure 3(c). - Continued.

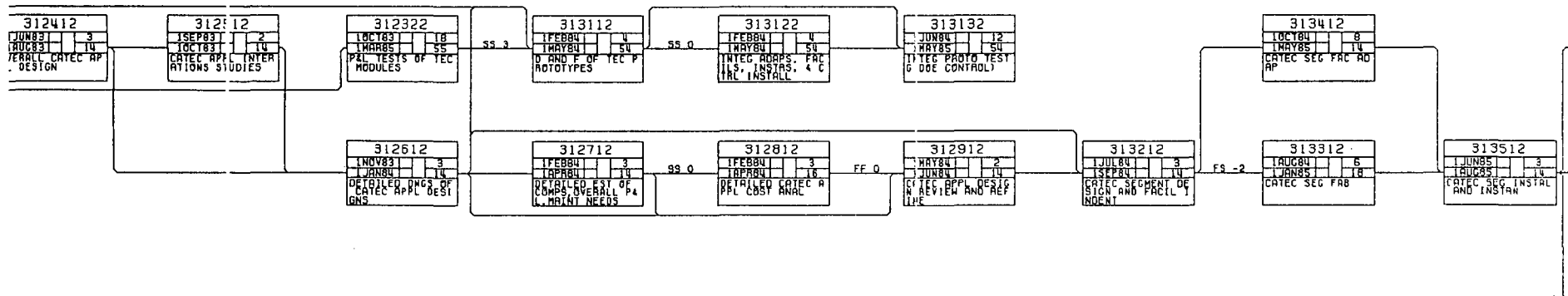


Figure 3(c). - Continued.

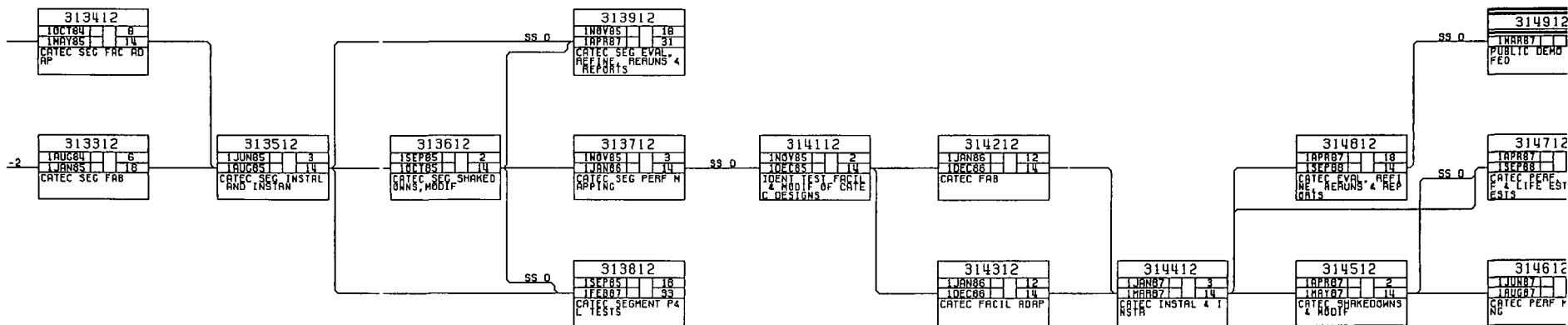


Figure 3(c). - Continued.

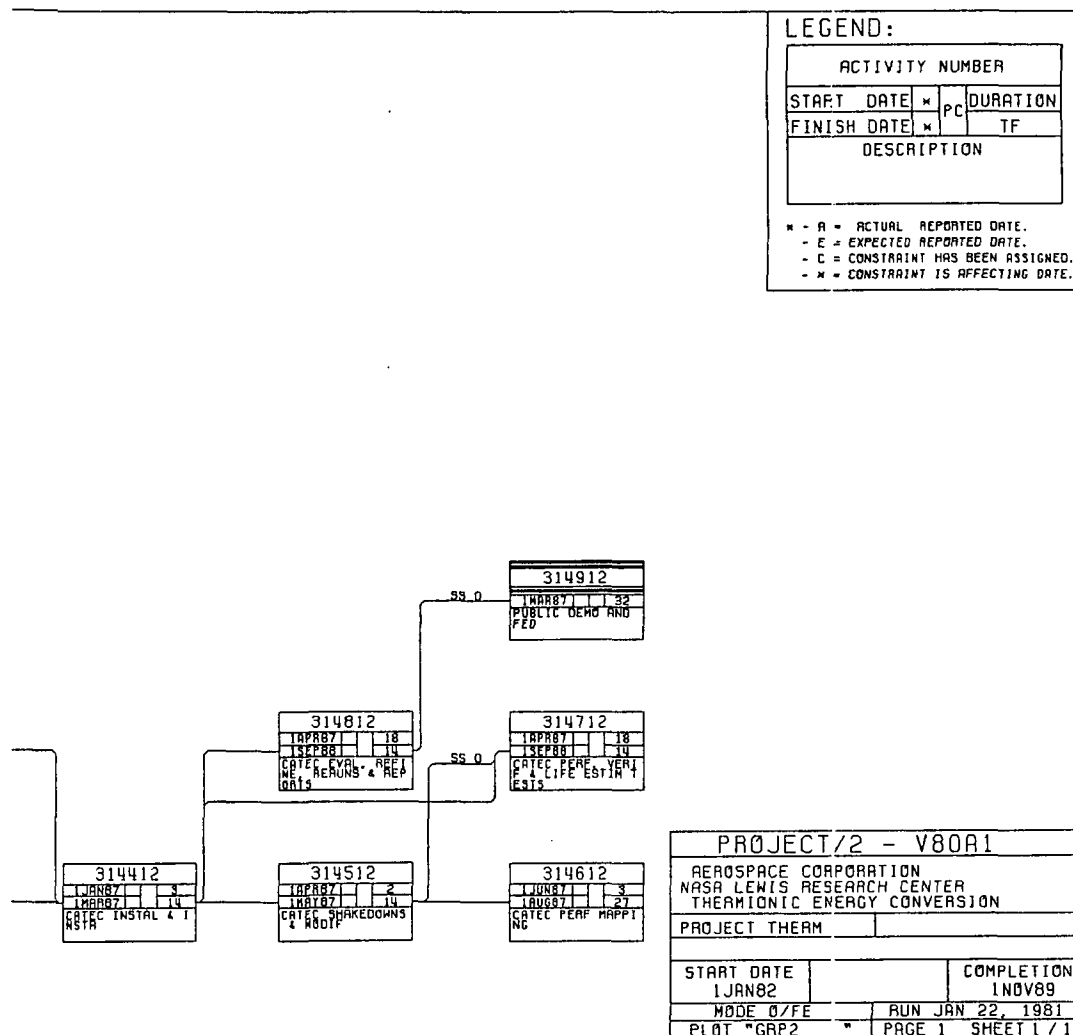


Figure 3(c). - Concluded.

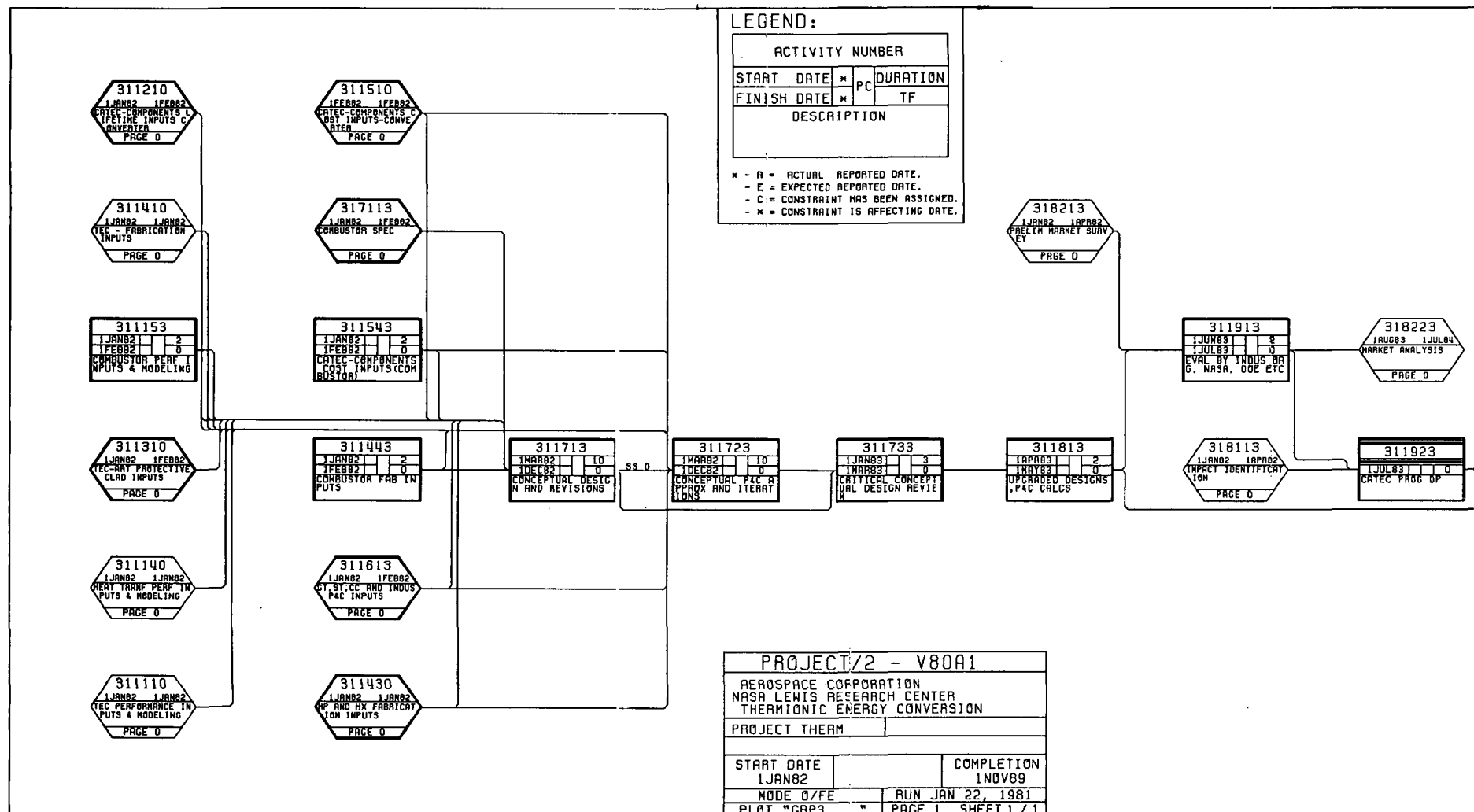


Figure 3(d). - Phase 3.

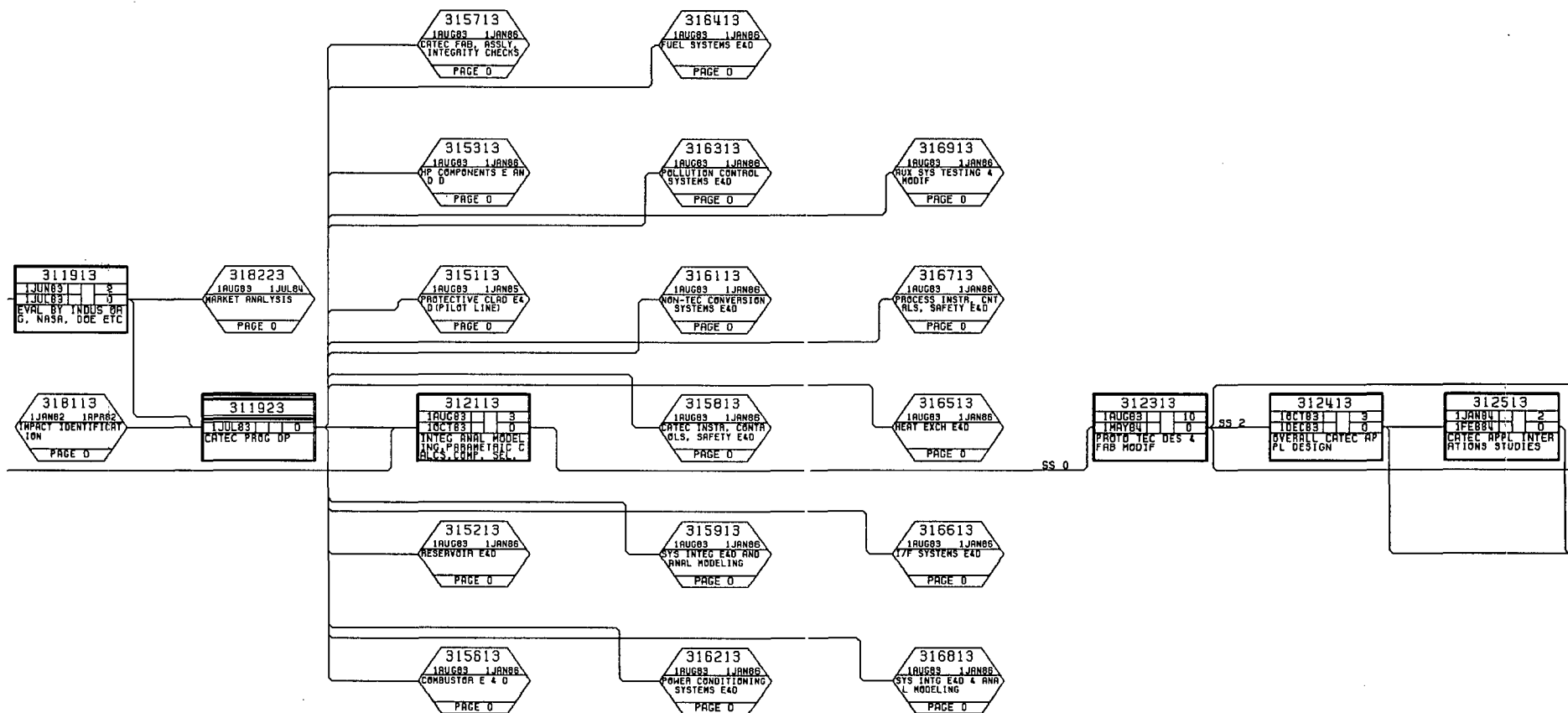


Figure 3(d). - Continued.

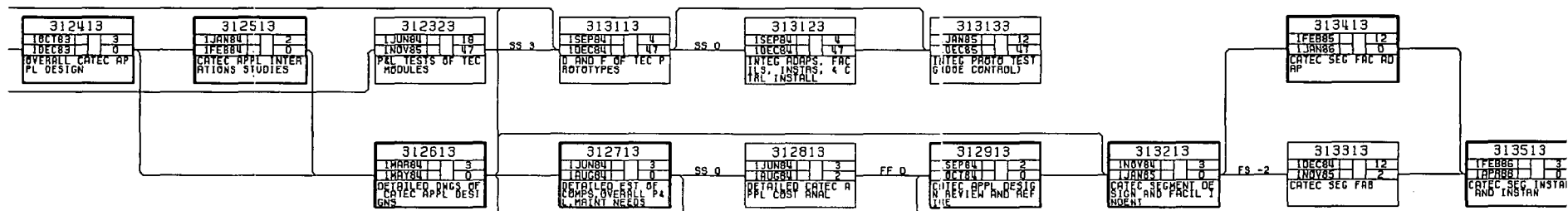


Figure 3(d). - Continued.

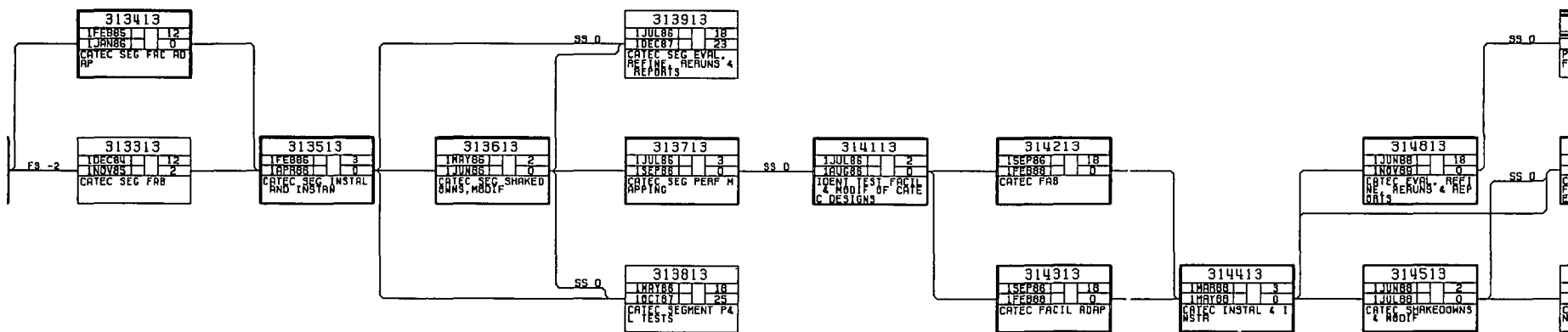


Figure 3(d). - Continued.

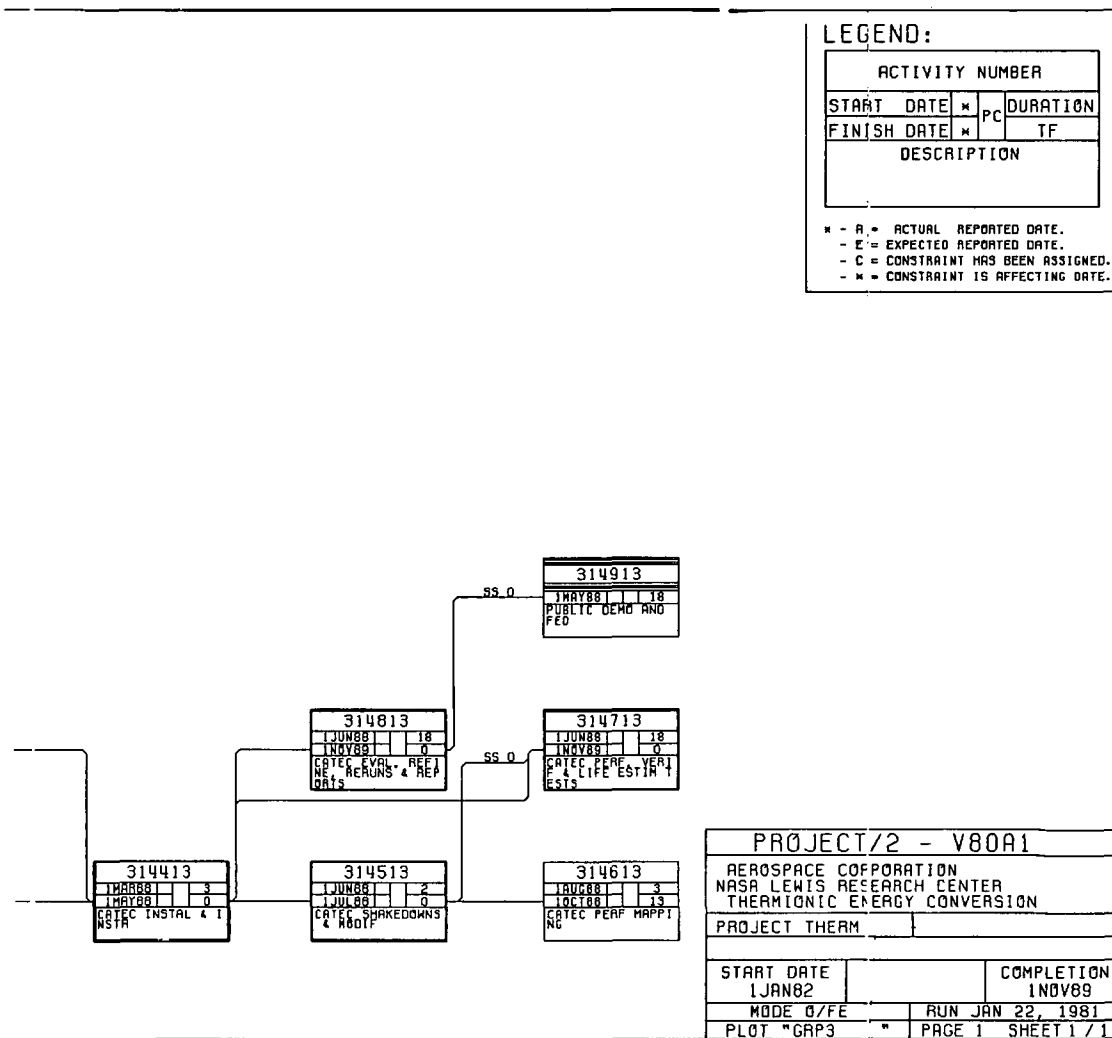


Figure 3(d), - Concluded.

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7. Author(s) James F. Morris, Lewis Research Center; Owen S. Merrill, U.S. Department of Energy, Washington, D.C.; and Harsha K. Reddy, The Aerospace Corp., Los Angeles, California				8. Performing Organization Report No. E-950	
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16. Abstract Thermionic energy conversion (TEC) deserves consideration for topping any conversion or process system that receives heat from an energy source at much higher temperatures: In recent TEC-topping analyses, overall plant efficiency (OPE) and cost of electricity (COE) improve slightly with current capabilities and substantially with fully matured technologies. And enhanced credibility derives from proven hot-corrosion protection for TEC by silicon-carbide clads in fossil-fuel combustion products. Combustion augmentation with TEC (CATEC) affords minimal cost and plant perturbation, but with smaller OPE and COE improvements than more conventional topping applications. However risk minimization as well as comparative simplicity and convenience favor CATEC for early market penetration. Therefore a program-management plan is apropos. That plan, its inputs, characteristics, outputs and capabilities are subjects of this report.					
17. Key Words (Suggested by Author(s)) Thermionic energy conversion (TEC) Combustion augmentation with TEC (CATEC) Terrestrial application Combined-cycle with coal gasification High temperatures high power densities			18. Distribution Statement Unclassified - unlimited STAR Category 75 DOE Category UC-90f		
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